Software User's Guide: URBEMIS2002 for Windows with Enhanced Construction Module

Version 7.4
Emissions Estimation for
Land Use Development Projects

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I. INTRODUCTION

URBEMIS2002 for Windows version 7.4, like its predecessors, is designed to estimate air emissions from land use development projects. The earliest versions of URBEMIS (URBEMIS versions 1 through 5) were designed to estimate only motor vehicle emissions from trips generated by land use development. URBEMIS2002 for DOS was enhanced to enable users to estimate construction and area-source emissions and to select mitigation measures for construction emissions, area sources, and motor vehicle trips. URBEMIS 2002 for Windows 5.1.0, which followed version URBEMIS2002 for DOS, was written to run in the Windows 95/98 environment. URBEMIS2001 for Windows 6.2.2, released in early 2001, allowed users to estimate motor vehicle emissions using the California Air Resources Board's EMFAC2001 emissions model (version 2.08).

The two major differences between URBEMIS2001 version 6.2.2. and URBEMIS2002, version 7.4, is that version 7.4 has an enhanced construction emissions module and uses EMFAC2002, version 2.2 emission rates. Other enhancements include the additional of several land uses, and an option that allows the user to conduct screening level analyses.

The flowchart shown in the following page (Figure 1) provides a conceptual overview of URBEMIS2002. Once the URBEMIS2002 program has been initiated, the user must first either select an existing project or start a new one. For new projects, the air district in which the project is located must be selected. Then, the user typically goes to the land uses module to enter land use information relevant to his project. Once land use information has been entered, the user must select the relevant construction, area, and operational assumptions that apply to the project. Mitigation measures can also be selected as applicable. Once all information has been selected for a project, the user clicks the results button to obtain the emission estimates. After reviewing the results, the user can either save the project or go back and edit the land use or construction/area/operational module assumptions for the project.

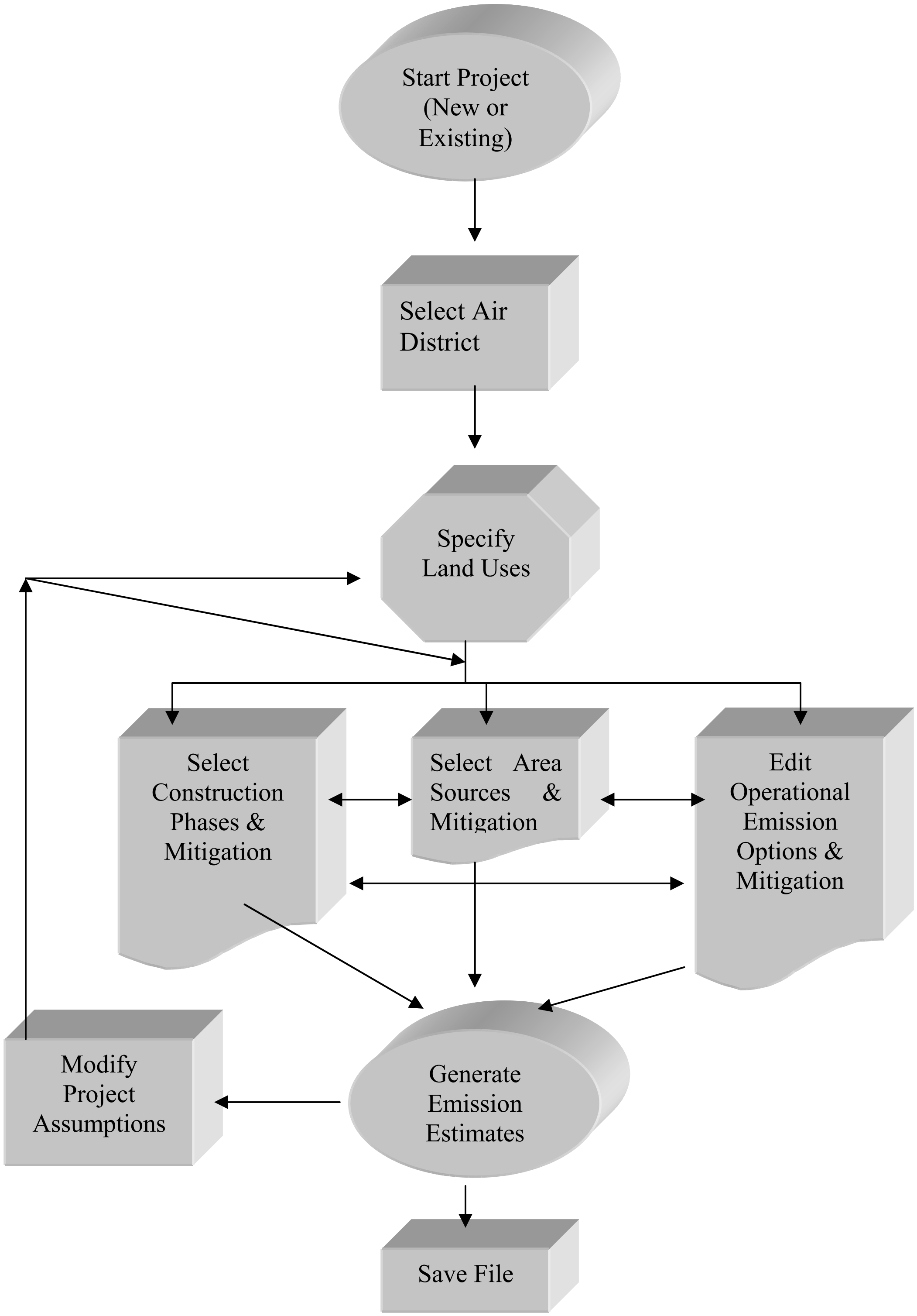

Figure 1. URBEMIS2002 Conceptual Flow Chart

II. GETTING STARTED

II.1 Memory Requirements

URBEMIS2002 is written in Microsoft Visual Basic for Windows, version 6.0. Unlike previous versions of URBEMIS, URBEMIS2002 for Windows does not have a memory limit when operating within the Windows 95/98/2000 environment except for the limits imposed by the computer on which it is installed.

II.2 Disk Limits

URBEMIS2002 requires substantial amounts of hard disk space, primarily to store EMFAC2002 files. The EMFAC2002 files require 61.6 megabytes of storage space. The remaining files, which include air district default files, the executable file, help file, and other miscellaneous supporting files, require less than 4 megabytes of hard disk space. In addition to these storage requirements, you should have at least one megabyte of additional hard disk space to store project files.

II.3 Installation

This description assumes that the required URBEMIS2002 files are first downloaded from either the South Coast or California Air Resources Board's website, then installed on a computer. A similar approach can be used if URBEMIS is being installed from a compact disk (CD).

Step one involves downloading the required files to your hard drive. This step can be skipped if you are installing from a CD. To do this, you will first need to choose the installer for your operating system, and click SAVE to a directory (folder) on your hard drive. Click on CLOSE after download is complete. The two options include:

Windows 2000 or NT operating system (service pack 6) OR
Windows 95, Windows 98 or Windows ME operating system

You will also need to download the following two files to the same location on your hard disk as your installer:

- URBEMIS 2002 for Windows.msi AND
- URBEMIS01.cab

Step two requires that you first install the installer, then the URBEMIS2002 software. Install the installer by double clicking on its file name (InstMsi.exe). This step can be skipped if the installer has already been installed on your computer or if you are installing on the Windows XP operating system because the installer is incorporated within Windows XP. Once the installer has been installed, double click URBEMIS 2002 for Windows.msi. Follow the installation instructions. When installation is complete, you will see a cloud icon on your desktop with the URBEMIS 2002 caption. To run the software, double click on the cloud icon. To save disk space, the three files used to install the program (InstMsi.exe, URBEM01.cab, URBEMIS 2002 for Windows.msi) can be deleted.

II.4 Starting URBEMIS2002

Once URBEMIS2002 has been successfully installed, it can be started by selecting the URBEMIS2002 icon from the desktop or by clicking on the Windows Start button, selecting Programs from the list, then selecting URBEMIS2002 from the list of programs.

One problem that frequently arises when starting URBEMIS2002 is that the program does not fit entirely within the computer screen. The optimal screen settings for running URBEMIS2002 are 1024 x 768 pixels, with the small fonts advanced setting option. These are Windows settings that can be changed by selecting the Start/Settings/Control Panel/Display from within the Windows operating system.

III. USING URBEMIS2002

III.1 Differences from Previous Versions

III.1.1 Additions

Several versions of URBEMIS have been released by the California Air Resources Board (ARB) since the early 1980s: Urbemis1, Urbemis2, Urbemis3, and Urbemis5, URBEMIS7G for DOS, URBEMIS7G for Windows, URBEMIS2001 version 6.2.2, and the current edition, URBEMIS2002 version 7.4. (Urbemis4 was not released for use by the public.) Previous versions of URBEMIS allowed the user to estimate motor vehicle emissions associated with vehicle trips generated by land use development projects. Generally, each new release of URBEMIS has been associated with ARB's update of its motor vehicle emission factors.

URBEMIS7G represented the successor to URBEMIS5. URBEMIS7G differed from URBEMIS5 in several ways. First, URBEMIS7G was an updated version of URBEMIS5 because it included EMFAC7G, ARB's California motor vehicle emission factors model.

Another difference is that, for the first time, URBEMIS7G provided users with the ability to estimate construction and area source emissions. In addition, URBEMIS7G gave the user the ability to select mitigation measures for construction, area source, and motor vehicle emissions, another option not available in previous versions. And, URBEMIS7G provided estimates of the emissions benefits of those mitigation measures.

URBEMIS7G also included a series of enhanced land use selection screens. The enhancements included additional land uses, updated trip generation rates, trip generation rates for certain land uses based on equations included in the ITE Trip Generation Manual Version 6.0 (Institute of Transportation Engineers 1996), and the option of specifying whether the project is located is an urban versus a rural environment.

Previous versions of URBEMIS did not allow for estimation of reentrained road dust. URBEMIS7G estimated road dust emissions for both paved and unpaved roads.

URBEMIS7G also allowed the user to select a new "double-counting" option. This option was designed to minimize double counting of internal vehicle trips between residential and nonresidential land uses. Finally, URBEMIS7G allowed users to select a new "pass-by trips" option. With this option selected, URBEMIS7G could be used to estimate vehicle trip emissions based on the percentage of primary trips, diverted linked trips, and pass-by trips assumed for specific land use types.

URBEMIS7G was superceded by URBEMIS7G for Windows. The primary advantage of this enhancement is that it allowed the user to estimate emissions from within the Windows operating system environment. Several other minor improvements were made to fix previously identified bugs. URBEMIS2001 was released in early 2002, following by this current release of URBEMIS2002 in March 2003. URBEMIS2001 incorporated EMFAC2001 emissions factors, while URBEMIS2002 incorporated EMFAC2002 emissions factors. Additionally, EMFAC2002 includes several additional land uses, contains a major enhancement to the construction emissions and mitigation measures module, and includes a screening analysis option.

III.1.2 Appearance

The appearance of URBEMIS2002 is similar to URBEMIS2001 and URBEMIS7G for Windows.

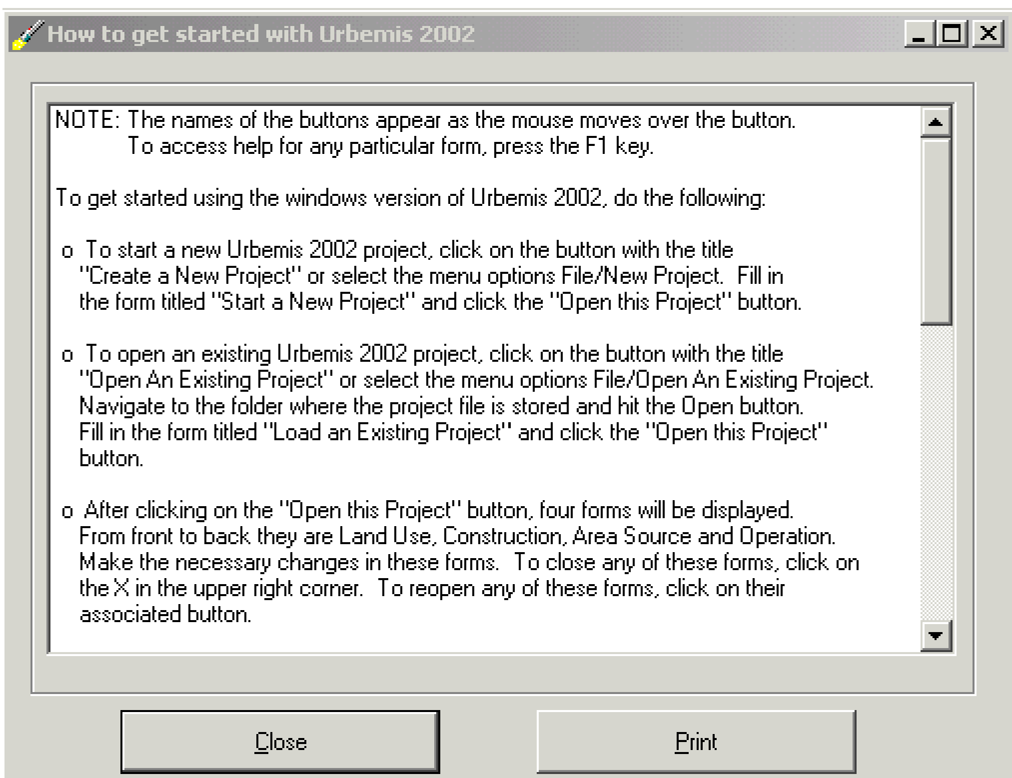

Figure 2. Introductory URBEMIS2002 for Windows Screen

When URBEMIS2002 is started, an introductory screen is presented that describes "How to Get Started with URBEMIS2002" (see Figure 2). That screen includes the basic information needed to start URBEMIS202. Once that introductory screen is closed, URBEMIS2002 shows the user the initial screen shown in Figure 3.

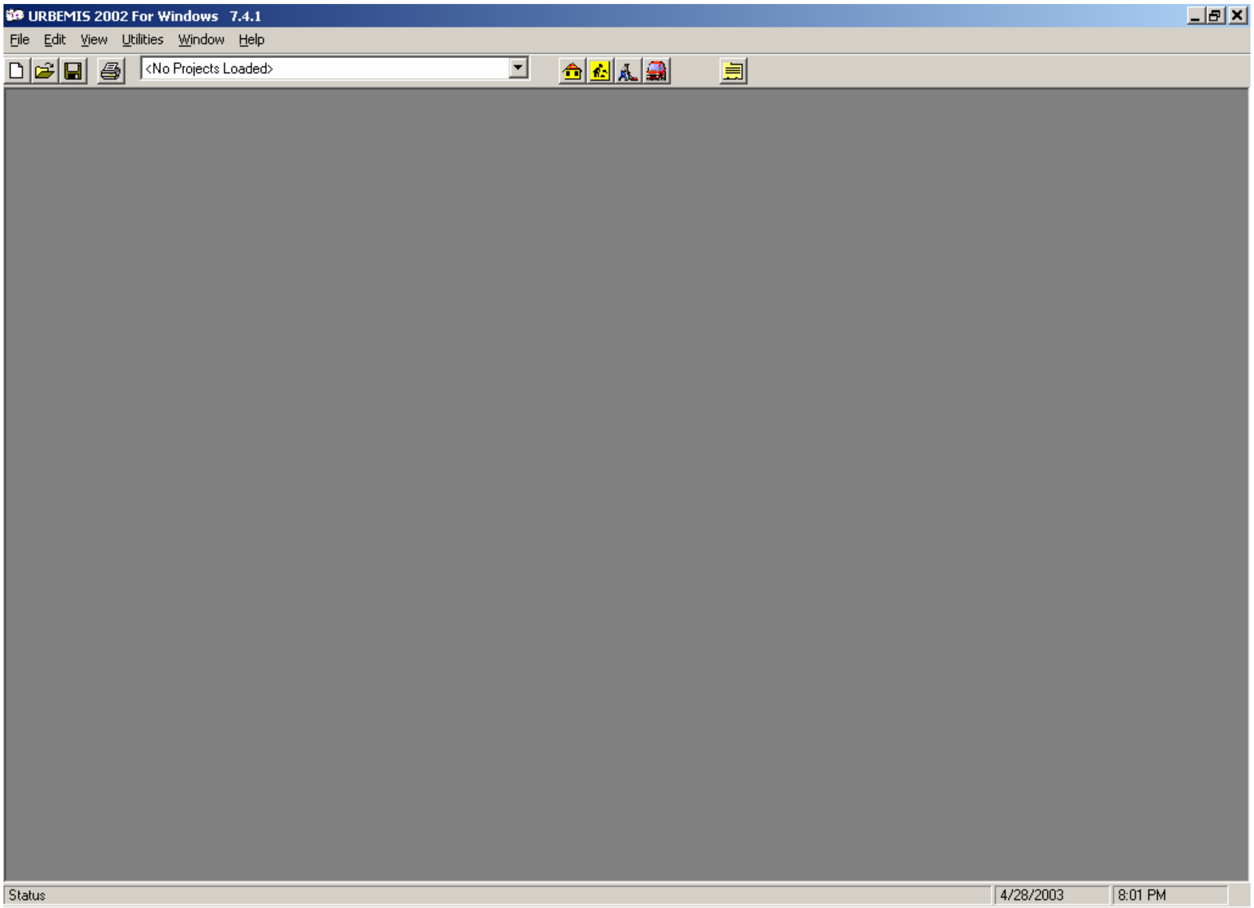

Figure 3. URBEMIS2002 Initial Screen

The screen is essentially blank except for a row of icons, referred to as the Icon Bar, and a row of words referred to as the Menu. On the icon bar, four icons are located to the left of the display showing which project is loaded. Those four icons, listed from left to right are the "Create a New Project" icon, "Open an Existing Project" icon, "Save Project Settings to File from Memory" icon, and the "Print Selected Results" icon. Five icons are located to the right of the display showing which project is loaded. The first four of these from left to right are the land uses icon, the construction emissions icon, the area source icon, and the operational (or motor vehicle icon). The icon is the view results icon, which allows the user to send the emission results to a file, a printer, or the screen.

III.1.4 File Structure

Due to several enhancements, URBEMIS2002 uses a different file structure than previous versions of URBEMIS, including URBEMIS2001 (and the beta version of URBEMIS2002.) Consequently, project files generated by previous versions of URBEMIS are not readable by URBEMIS2002. Attempting to read files from previous versions will generate an error message.

III.2 Program Overview

Upon starting URBEMIS2002, you are taken to the "How to Get Started with URBEMIS2002 screen. This screen contains instructions for quickly starting the URBEMIS2002 program (see Figure 2 above).

III.2B Setting Directories

Upon starting URBEMIS2002, you are shown the URBEMIS2002 main menu. You should ensure that the directories are set correctly (see Section III.10, "Setting Default Drives and Directories") before proceeding. The directories specify where URBEMIS2002 reads files from and writes them to.

III.3 Beginning a New Project

From the initial screen, you begin a new project by either selecting "File" from the Menu, then selecting "New Project" from the drop down menu. Alternatively, you may select from the Menu the left most icon (white sheet of paper icon) for New Project. Once you have selected the "New Project" option, URBEMIS2002 loads a screen entitled: "Start a New Project" (See Figure 4). That screen requires the user to enter a project description and to select the air basin or air district in which the project will be located (one of up to ten air basins or air districts). By selecting the air basin location, the associated default information for that basin is loaded into the project emissions source categories (construction, area, and operational) for which emissions will be calculated. The information included in the default file has been supplied by the respective air district(s). The project setting and the project emission source categories can be modified by the user by clicking the "edit these project settings" button.

Two buttons are included on this screen that allows the user to "Open Project Without Forms Showing" or "Open Project with Forms Showing". One of these two buttons must be selected in order to proceed to the next screen. If the user opts for the "Open Project With Forms Showing" button, then URBEMIS2002 loads the land use screens and the project emission source screens (construction, area, and/or operational). If the "Open Project Without Forms" button is clicked, then URBEMIS2002 presents the user with the icon bar and an empty screen (see Figure 3). The user must then click on the land use screen (house) icon to continue entering information on the new project.

One addition to the new project screen is the "screening analysis mode" checkbox located just to the right of the project description. (Please note: the "screening analysis mode" can not be selected if your project is located within the South Coast Air Basin.) If the user clicks on the screening analysis mode checkbox, then to proceed to subsequent screens, the user must click on the "Open this Screen Analysis" button that appears. By selecting screening analysis, the user will not be able to edit the default values for construction, area sources, or operational emissions. In addition, because the construction module depends on several key assumptions that must be reviewed by the user, the screening analysis mode only allows emissions to be estimated for the area and operational source categories.

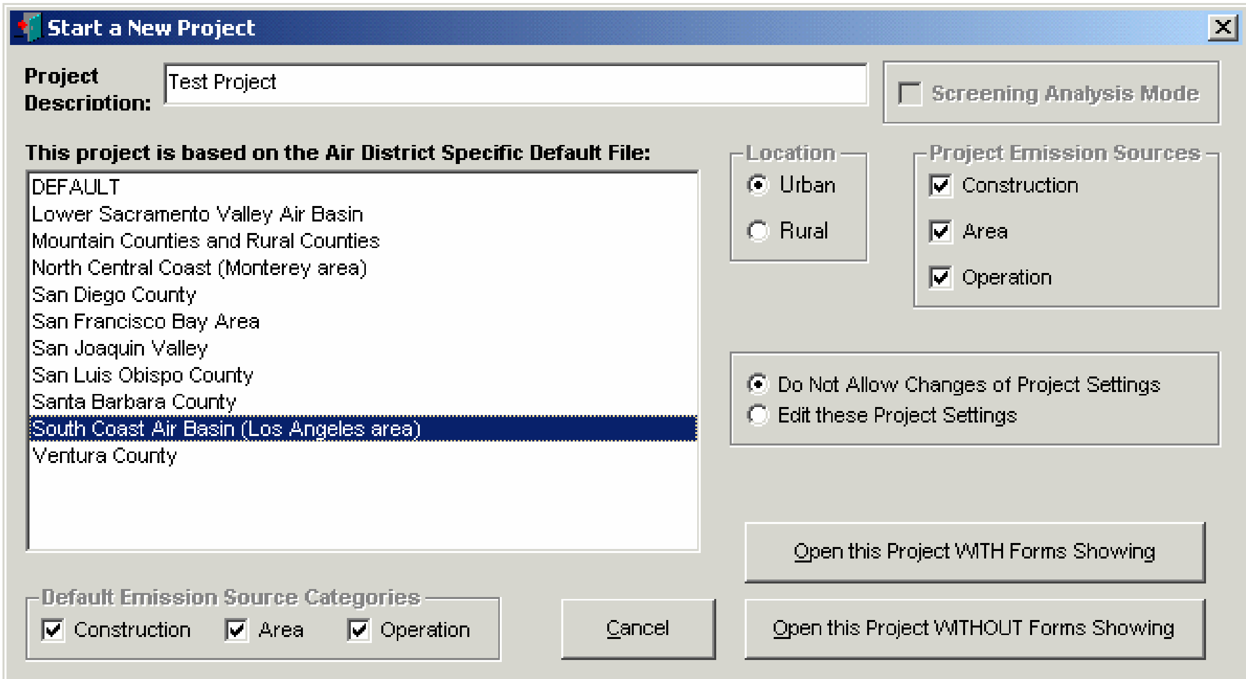

Figure 4. New Project Screen

III.4 Open an Existing Project

From the default menu, you open an existing project by selecting "File" from the Menu, , then selecting "Open an Existing Project" from the drop down menu. Or, alternatively, from the Icon Bar select the icon located on the second from the left (looks like a manila folder). If you select the "Open an Existing Project" option, URBEMIS2002 loads a screen entitled: "Select a Project File". At this point you must either double-click on the name of one of the files listed, enter the name of the file, or change the directory from which you want to select a file. If you enter a file name that does not exist in the selected directory, URBEMIS2002 flashes a message telling you that the selected file does not exist. **Please note: URBEMIS2002 uses a different file structure than previous versions of URBEMIS, including URBEMIS2001. If you attempt to load a file created with an earlier version of URBEMIS, you will get an error message.**

Once the user has opted to open an existing project, URBEMIS shows a screen (Figure 5) that allows the user to edit the project description, air district default file, project setting (rural versus urban), and project emissions source categories (construction, area, operational).

By selecting the air basin location, the associated default information for that basin is loaded into the project setting, and project emissions source categories (construction, area, and operational) for which emissions will be calculated. The information included in the default file has been supplied by the respective air district(s). The project environment and the project emission source categories can be modified by clicking the “edit these project settings” button.

Two buttons are included on this screen that allows the user to “Open Project Without Forms Showing” or “Open Project with Forms Showing”. One of these two buttons must be selected in order to proceed to the next screen. If the user opts for the "Open Project With Forms Showing" button, then URBEMIS2002 loads the land use screens and the project emission source screens (construction, area, and/or operational). If the "Open Project Without Forms" button is clicked, then URBEMIS2002 presents the user with the icon bar and an empty screen (see Figure 3). The user must then click on the land use screen (yellow house) icon to continue editing the existing information on the project. Alternatively, the user can select the construction (construction worker with shovel icon), area (lawn mower operator icon), or the operational (red car icon) buttons to review or edit the default assumptions.

One addition to the new project screen is the "screening analysis mode" checkbox located just to the right of the project description. If the user clicks on that checkbox, then to proceed to subsequent screens, the user must click on the "Open Screening Analysis" button that appears. By selecting screening analysis, the user will not be able to edit the default values for construction, area sources, and operational emissions. In addition, because the construction module depends on several key assumptions that must be reviewed by the user, the screening analysis mode only allows emissions to be estimated for the area and operational source categories.

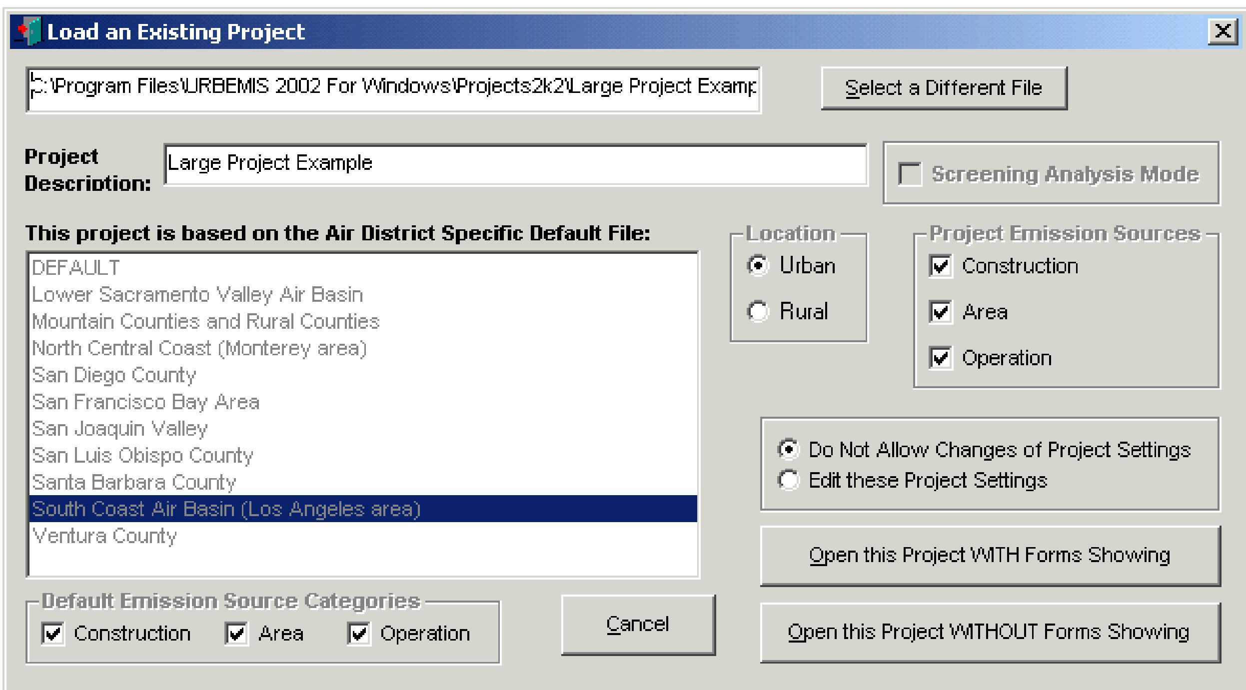

Figure 5. Load an Existing Project Screen

III.5 Specifying Land Uses

If you opt to open a project with all forms open, then URBEMIS presents the form shown in Figure 6. The land uses screen is shown in front of construction, area sources, and operational emissions screens. The first land use screen displays the first of seven possible land use screens, which are organized as follows:

- residential;
- educational;
- recreational;
- large retail;
- retail
- commercial and;
- industrial.

You may access the land uses associated with either of the seven land use screens by clicking on the appropriate tab.

If you have opted to open a project without having the forms automatically opened, then you will have to manually open the land use screens by clicking on the land use (yellow house) icon on the Icon Bar

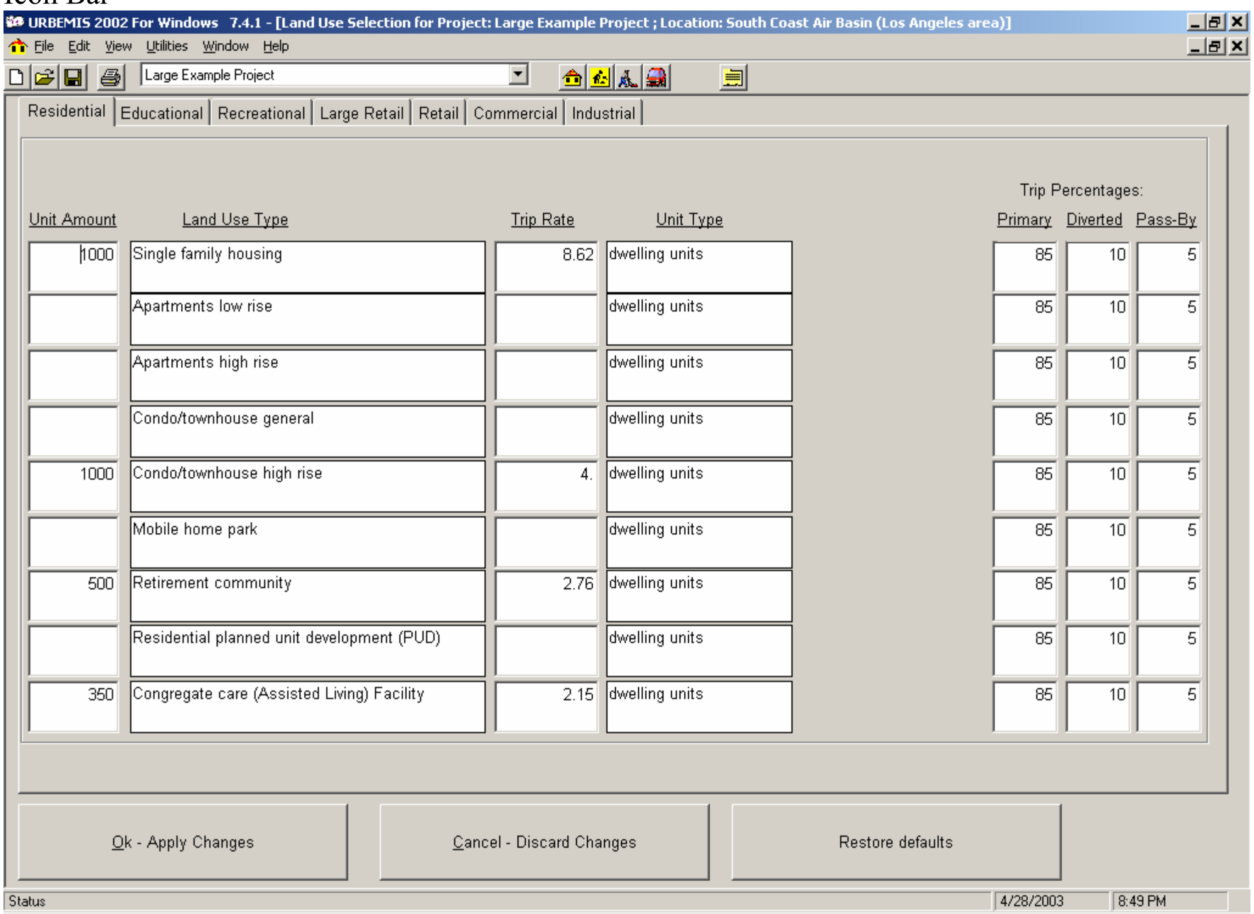

Figure 6. Land Uses Screen

Table 1 lists each of the URBEMIS2002 land uses, provides a definition of each land use, and shows the percentage of worker commute trips associated with each land use. Those percentages are called Percent Worker Commute in Table 1.

For each land use type, you are given the option of entering the project size or unit amount. URBEMIS2002 automatically calculates the trip rate based on the unit amount, using information taken from the ITE Trip Generation Manual, 6th edition (Institute of Transportation Engineers, 1997). For certain land uses, if the unit amount entered by the user is too small, no trip rate is estimated. The reason for this is that the trip rate equations are based on land uses representing a range of sizes. When a unit amount is outside that range, the equation produces invalid trip generation rates. For example, URBEMIS will not generate a trip generation rate if less than 30 units are entered for the condo/townhouse high rise. In such cases, the user must enter their own trip rate. For 30 or more condo/townhouse high rise units, however, URBEMIS does calculate trip generation rates.

The equation or value used to estimate trip generation is shown in Table 2. You can override the trip rate by typing in a different rate. For certain land uses, you also can select a different unit type by clicking on the "Unit Type" arrow (if it is shown for that particular land use). If a land use's unit type does not have an arrow, then you can simply edit the name of the unit type. You can also edit the name of the land use type.

For all non-residential land uses, you also have the option of modifying the default "% Worker Commute" value. This value represents the percentage of worker commute trips attracted to that land use as a percentage of all trips generated by that land use.

Once you have finished entering land uses, you must click the OK-Apply Changes button to save those changes to memory. Please note that by clicking on OK-Apply Changes button will not save those changes to a file. Saving changes to a file is described in Section III-11.

Table 1. Land Use Definitions and Percent Worker Commute

	Land Use Definition	Percent Worker Commute
First Land Use Screen: Residential		
Single Family Housing	Detached homes on individual lots	N/A
Apartments, Low Rise	Buildings with one to ten stories	N/A
Apartments, High Rise	Buildings with more than ten floors	N/A
Condo/Townhouse General	Condos and townhomes in buildings with one or two levels.	N/A
Condo/Townhouse High Rise	Condos and townhomes in buildings with 3 or more levels.	N/A
Mobile Home Park	Trailers sited and installed on permanent foundations.	N/A
Retirement Community	Self-contained villages restricted to adults or senior citizens	N/A
Residential Planned Unit Development (PUD)	Residential planned unit developments can included any combination of residential land uses and may contain supporting services such as limited retail and recreational facilities.	N/A
Assisted Living	One or more multiunit buildings designed for elderly living and may contain dining rooms, medical, and recreational facilities.	N/A
Second Land Use Screen: Educational		
Day-Care Center	Facilities that care for pre-school children, normally during daytime hours. May also include after-school care for older children.	5
Elementary School	Generally includes Kindergarten through either 6th or 8th grades.	20
Junior High School	Includes 7th, 8th, and often 9th grades.	20
High School	Includes 10th, 11th, and 12th grades and oftentimes 9th grade.	10
Junior College (2 years)	Most have facilities separate from other land uses and exclusive access points and parking facilities.	5

University/College (4 years)	Four year and graduate educational institutions.	5
Library	Public or private facility, which houses books, and includes reading rooms and possibly meeting rooms.	5
Place of Worship	Building(s) providing public worship services.	3
Blank (Edit all 5 columns)	Blank commercial land use that can be entered by the URBEMIS2002 user.	2

Third Land Use Screen: Recreational

City Park	Owned and operated by a city, these facilities can vary widely as to location, type, and number of facilities. May including boating, swimming, ball fields, camp sites, and picnic facilities.	
Racquet Club	Privately owned facilities with tennis, racquetball, and/or handball courts, exercise rooms, and/or swimming pools and/or weightrooms	5
Racquet/Health Club	Privately owned facilities with tennis, racquetball, and/or handball courts.	5
Quality Restaurant	Typically with customer turnover rates of at least one hour.	8
High Turnover (sit-down Restaurant)	Typically with high customer turnover rates of less than one hour.	5
Fast Food Restaurant with Drive Through	Includes fast food restaurants with drive through windows, such as McDonald's, Burger King, and Taco Bell.	5
Fast Food Restaurant without Drive Through	Includes fast food restaurants without drive through windows, such as McDonald's, Burger King, and Taco Bell.	5
Hotel	Place of lodging providing sleeping accommodations, restaurants, and meeting or convention facilities.	5
Motel	Place of lodging providing accommodations and often, a restaurant.	5

Fourth Land Use Screen: Large Retail

Free-Standing Discount Store	Free-standing store with off-street parking,	2

	can be part of neighborhood shopping centers.	
Free-Standing Discount Superstore	Same as free-standing discount store but also include full service grocery department under the same roof.	2
Discount Club	Discount/warehouse store whose shoppers pay a membership fee to take advantage of discounted prices.	2
Regional Shopping Center	Integrated group of commercial establishments that are planned, developed, owned, and managed as a unit.	2
Electronics Superstore	Free-standing warehouse type facilities specializing in the sale of home and vehicle electronic merchandise, as well as TVs, compact disc and cassette tape players, cameras, radios, videos, and general electronic accessories.	2
Home Improvement Superstore	Free-standing warehouse type facilities specializing in lumber, tools, paint, lighting, wallpaper and paneling, kitchen and bathroom fixtures, lawn equipment, and garden plants and accessories.	2

Fifth Land Use Screen: Retail

Strip Mall	Neighborhood store complexes with a variety of retail outlets.	2
Hardware/Paint Store	Stores selling general hardware items and/or paints and supplies.	2
Supermarket	Free-standing stores selling a complete assortment of food, food preparation and wrapping materials, and household cleaning and servicing items. May also contain money machines, photo centers, pharmacies, and video rental areas.	2
Convenience market (24 hour)	These markets sell convenience foods, newspapers, etc. and do not have gasoline pumps. (Trip generation rates with gas pumps is approximately 12% higher than without.	2
Convenience market with gas pumps	These markets sell convenience foods, newspapers, etc. and do have gasoline pumps.	2

Gasoline/Service Station	Excludes gasoline stations with convenience stores or car washes.	2
Sixth Land Use Screen: Commercial		
Bank (with drive-through)	Banks with one or more drive-up windows.	2
General Office Building	Houses multiple tenants in a location where affairs of businesses, commercial or industrial organizations or professional persons or firms are conducted.	35
Office Park	Contain general office buildings and related support services, arranged in a park- or campus-like setting.	48
Government Office Building	Individual building containing the entire function or simply one agency of a city, county, state, or federal government.	10
Government (Civic Center)	Group of government buildings connected with pedestrian walkways	10
Pharmacy/Drugstore with Drive Through	Retail facilities selling prescription and non-prescription drugs. Also typically sell cosmetics, toiletries, medications, stationary, personal care products, limited food products, and general merchandise. These facilities include a drive-through window.	2
Pharmacy/Drugstore without Drive Through	Retail facilities selling prescription and non-prescription drugs. Also typically sell cosmetics, toiletries, medications, stationary, personal care products, limited food products, and general merchandise. These facilities do not contain a drive-through window.	2
Medical Office Building	Includes both medical and dental office buildings that provide diagnoses and outpatient care. Generally operated by one ore more private physicians or dentists.	7
Hospital	Any institution where medical or surgical care is give to non-ambulatory and ambulatory patients and overnight accommodations are provide.	25

Seventh Land Use Screen: Industrial		
Warehouse	Buildings devoted to the storage of materials, also include office and maintenance areas.	2

General Light Industry	Typical light industrial activities include: print plants, material testing labs, and assemblers of data processing equipment. They employ fewer than 500 persons and tend to be free-standing.	50
General Heavy Industry	Could also be categorized as manufacturing facilities. However, heavy industrial uses are limited to the production of large items.	90
Industrial Park	Contain a number of industrial or related facilities and are characterized by a mix of manufacturing, service, and warehouse facilities. May contain highly diversified facilities, a number of small businesses, or one or two dominant industries.	41.5
Manufacturing	Sites where the primary activity is the conversion of raw materials or parts into finished products. May also included associated office, warehouse, research, and other functions.	48

Percent worker commute represents the percentage of total trips that are work-related commute trips.

Table 2. URBEMIS2002 Trip Generation Rates

Land Use	Trip Generation Rate Fitted Curve Equation or Average Rate	X or Units *	Source
Single Family Housing	Ln(T) = 0.920 Ln(X) + 2.707	Dwelling Unit	ITE (210)
Apartment, Low Rise	(T) = (5.124 (X) + 387.526)	Dwelling Unit	ITE (221)
Apartment, High Rise	Ln(T) = 0.825Ln(X)+2.502	Dwelling Unit	ITE (222)
Condominium/Townhouse, General	Ln(T) = 0.850 Ln(X) + 2.564	Dwelling Unit	ITE (230)
Condominium/Townhouse, High Rise	Ln(T) = 3.771 Ln(X) + 233.657	Dwelling Unit	ITE (232)
Mobil Home Park	Ln(T) = 3.274 Ln(X) + 300.864	Dwelling Unit	ITE (240)
Retirement Community	2.76	Dwelling Unit	ITE (250)
Residential Planned Unit Development (PUD)	Ln(T)=0.880Ln(X) + 2.819	Dwelling Unit	ITE (270)
Congregate Care (Assisted Living) Facility	2.15	Dwelling Unit	ITE
Day-Care Center	79.3	1000 sq. ft.	ITE (565)
Elementary School	Ln(T) = 0.718 Ln(X) + 3.496	1000 sq. ft.	ITE (520), 5th edition
Elementary School	Ln(T) = 1.007 Ln(X) – 0.086	Student	ITE (520)
Junior High School	11.92	1000 sq. ft.	ITE (522)
Junior High School	Ln(T) = 1.559 Ln(X) – 3.507	Student	ITE (522)
High School	Ln(T) = 0.721 Ln(X) + 3.759	1000 sq. ft.	ITE (530), 5th edition
High School	T = {[(0.420/X) + 0.00027]**-1}	Student	ITE (530), 5th edition
Junior College (2 Years)	18.36	1000 sq. ft	ITE (540)
Junior College (2 Years)	T=1.450(X) + 610.265	Student	ITE (540)
University/College (4 Years)	T = 2.229(X) +439.995	Student	ITE (550)
Library	Ln(T) = 0.681 Ln(X) + 5.043	1000 sq. ft.	ITE (590)
Place of Worship	9.11	1000 sq. ft.	ITE (560)
City Park	50	Acre	Sandag, 1996
Racquet Club	17.14	1000 sq. ft.	ITE (492)
Racquetball/Health Club	40	1000 sq. ft.	Sandag, 1996
Quality Restaurant	Ln(T) = 0.900 Ln(X) + 4.746	1000 sq. ft.	ITE (831) 5th Edition Update
High-Turnover (Sit-Down) Restaurant	130.34	1000 sq. ft.	ITE (832)
Fast-Food Restaurant w/o Drive-Through Window	716	1000 sq. ft.	ITE (833)
Fast-Food Restaurant with Drive-Through Window	496.1	1000 sq. ft.	ITE (834)
Hotel	T = 8.946(X) – 368.112	Rooms	ITE (310)
Motel	Ln(T) = 0.973 Ln(X) + 2.298	Rooms	ITE (320)
Free-Standing Discount Store	Ln(T) = 1.654 LN(X) + 0.911	1000 sq. ft.	ITE (815)
Free-Standing Discount Superstore	T = 59.492(X) - 1930.270	1000 sq. ft.	ITE (813)
Discount Club	41.8	1000 sq. ft.	ITE (861)
Regional Shopping Center	Ln(T) = 0.643 Ln(X) + 5.866	1000 sq. ft.	ITE (820)
Electronics Superstore	45.0	1000 sq. ft.	ITE(863)

Home Improvement Superstore	T = 37.403(X) – 235.069	1000 sq. ft.	ITE(862)
Strip Mall	40	1000 sq. ft.	Sandag, 1996
Hardware/Paint Store	51.3	1000 sq. ft	ITE(816)
Supermarket	111.51	1000 sq. ft.	ITE(850)
Convenience Market (24 hr.)	737.99	1000 sq. ft.	ITE (851)
Convenience Market with Gasoline Pumps	845.6	1000 sq. ft.	ITE (853)
Gasoline /Service Station	168.56	Fueling Positions	ITE (844)
Bank (with Drive-Through)	T = 174.529(X) + 385.789	1000 sq. ft.	ITE (912)
General Office Building	Ln(T) = 0.768 Ln(X) + 3.654	1000 sq. ft.	ITE (710)
Office Park	T =10.422(X) + 409.04	1000 sq. ft.	ITE (750)
Government Office Building	68.9	1000 sq. ft.	ITE (730)
Government (Civic Center)	30	1000 sq. ft.	SANDAG
Pharmacy/Drugstore without Drive Through	Ln(T) = 0.994 Ln(X) + 4.510	1000 sq. ft	ITE(880)
Pharmacy/Drugstore with Drive Through	88.16	1000 sq. ft	ITE(881)
Medical/Dental Office Building	T = 40.892(X) - 214.97	1000 sq. ft.	ITE (720)
Hospital	T = 10.411(X) + 1915.686	1000 sq. ft.	ITE (610)
Hospital	T = 7.38 (X) + 1718.324	Beds	ITE (610)

Warehouse	T = 3.576(X) + 350.266	1000 sq. ft.	ITE(150)
General Light Industry	T = 7.468(X) - 101.921	1000 sq. ft.	ITE (110)
General Light Industry	T = 42.223(X) + 263.112	Acre	ITE (110)
General Light Industry	T = 2.951(X) + 30.572	Employee	ITE (110)
General Heavy Industry	1.5	1000 sq. ft.	ITE (120)
General Heavy Industry	6.75	Acre	ITE (120)
Industrial Park	T = 4.963(X) + 747.746	1000 sq. ft.	ITE (130)
Industrial Park	T = 47.943(X) + 595.337	Acre	ITE (130)
Industrial Park	Ln(T) = 0.796Ln(X) + 2.572	Employee	ITE (130)
Manufacturing	T = 3.881(X) – 20.702	1000 sq. ft.	ITE (140)

Notes

T = Average Vehicle Trip Ends
sq. ft. = Square Feet
GLA = Gross Leasable Area
N/A = Data Not Available
SANDAG = San Diego Association of Governments
All trip generation rates from ITE, 6th Edition unless otherwise noted.
* "Dwelling unit" is a residential housing unit (including 'single room occupancy' units and 'granny flats'). "Square feet" refers to the total floor area (on all levels) of buildings, but does not include parking structures even if they are within a building (also known as 'gross leasable area'). "Acres" refers to the gross surface of the entire site, including any structures, streets, sidewalks, parking, and landscaping (but not including building or parking lot floor areas above the first level).

Similar to the free-standing discount stores with the exception that the superstores also contain a full service grocery department.

A discount store/warehouse whose shoppers pay a membership fee in order to take advantage of discounted prices.

Pass-by Trips

URBEMIS2002 allows users to select a pass-by trip option, which results in lower operational emissions. If the default pass-by trip information is changed, the URBEMIS report ("changes to default" option) shows that the default values have been changed.

The pass-by trip option splits trips into percentages of primary, pass-by, and diverted-linked trips. Primary trips are trips made for the specific purpose of visiting the designated land use. The stop at that trip generator is the primary reason for the trip. Pass-by trips are trips made as intermediate stops on the way from an origin to a primary trip destination. Pass-by trips are attracted from traffic passing the site on an adjacent street that contains direct access to the generator. Diverted-linked trips are trips attracted from the traffic volume on roadways in the vicinity of the generator but which require a diversion from that roadway to another roadway to gain access to the site.

When the pass-by option is turned off, URBEMIS assumes all trips are primary trips. When pass-by is turned on, lower emissions result because a percentage of trips associated with each land use is assumed to be pass-by and diverted linked trips (see Table 3). Pass-by and diverted-linked trips have a lower trip distance than primary trips. URBEMIS assumes that pass-by trips result in virtually no extra travel, with an assumed trip length of 0.01 miles. Diverted-linked trip lengths are assumed to equal 25% of the primary trip length.

As shown in Table 3, the "fast-food restaurant without drive-through window" land use consists of 50% primary trips, 40% diverted linked trips, and 10% pass-by trips. Assuming a trip length of 10 miles, emissions calculated using the pass-by trip option would be calculated by assuming that 50% of the trips would be 10 miles, 40% of the trips would be 2.5 miles, and 10% of the trips would be 0.01 miles.

Unlike URBEMIS2002, previous versions of URBEMIS did not present the primary/pass-by/diverted-linked trip percentages on screen. The individual air districts have the option of determining whether the URBEMIS end-user can modify those percentages for projects within their jurisdiction.

Table 3. URBEMIS Land Uses Sorted by Category with Trip Percentages

Land Use	Land Use Category	Primary Trip (%)	Diverted Linked Trip (%)	Pass-By Trip (%)	Source
Single-Family Housing	Residential	85	10	5	Sandag 1996
Apartment, Low Rise	Residential	85	10	5	Sandag 1996
Apartment, High Rise	Residential	85	10	5	Sandag 1996
Condominium/Townhouse, General	Residential	85	10	5	Sandag 1996
Condominium/Townhouse, High Rise	Residential	85	10	5	Sandag 1996
Mobile Home Park	Residential	85	10	5	Sandag 1996
Retirement Community	Residential	85	10	5	Sandag 1996
Residential Planned Unit Development (PUD)	Residential	85	10	5	Sandag 1996
Congregate Care (Assisted	Residential	85	10	5	Sandag 1996

Land Use	Land Use Category	Primary Trip (%)	Diverted Linked Trip (%)	Pass-By Trip (%)	Source
Living) Facility					
Day-Care Center	Educational	25	60	15	Sandag 1996
Elementary School	Educational	60	25	15	Sandag 1996
High School	Educational	75	20	5	Sandag 1996
Junior High School	Educational	65	25	10	Sandag 1996
Junior College (2 Years)	Educational	95	5	0	Sandag 1996
University/College (4 Years)	Educational	90	10	0	Sandag 1996
Library	Educational	45	45	10	Sandag 1996
Church	Educational	65	25	10	Sandag, 1996
City Park	Recreational	70	25	5	Sandag 1996
Racquet Club	Recreational	50	40	10	Sandag 1996
Racquetball/Health Club	Recreational	50	40	10	Sandag 1996
Quality Restaurant	Recreational	50	40	10	Sandag 1996
High-Turnover (Sit-Down) Restaurant	Recreational	30	40	30	ITE 1997
Fast-Food Restaurant without Drive-Through Window	Recreational	50	40	10	Sandag 1996
Fast-Food Restaurant with Drive-Through Window	Recreational	30	30	40	ITE 1997
Hotel	Recreational	60	35	5	Sandag 1996
Motel	Recreational	60	35	5	Sandag 1996
Free-Standing Discount Store	Large Retail	45	45	10	Sandag 1996
Free-Standing Discount Superstore	Large Retail	55	40	5	ITE 1997
Discount Club	Large Retail	55	40	5	Sandag 1996
Regional Shopping Center	Large Retail	55	35	10	Sandag 1996
Electronics Superstore	Large Retail	45	40	15	Sandag 1996
Home Improvement Superstore	Large Retail	45	40	15	Sandag 1996
Strip Mall	Retail	45	40	15	Sandag 1996
Hardware/Paint Store	Retail	45	40	15	Sandag 1996
Supermarket	Retail	45	40	15	Sandag 1996
Convenience Market (24 hr.)	Retail	25	30	45	ITE 1997
Convenience Market (w/gas pumps)	Retail	25	30	45	ITE 1997
Gasoline/Service Station	Retail	20	40	40	ITE 1997
Bank (with Drive-Through)	Commercial	35	45	20	Sandag 1996
General Office Building	Commercial	75	20	5	Sandag 1996

Land Use	Land Use Category	Primary Trip (%)	Diverted Linked Trip (%)	Pass-By Trip (%)	Source
Office Park	Commercial	80	15	5	Sandag 1996
Government Office Building	Commercial	50	35	15	Sandag 1996
Government (Civic Center)	Commercial	50	35	15	Sandag 1996
Pharmacy/Drugstore with Drive Through	Commercial	45	40	15	Sandag 1996
Pharmacy/Drugstore without Drive Through	Commercial	45	40	15	Sandag 1996
Medical Office Building	Commercial	60	30	10	Sandag 1996
Hospital	Commercial	75	25	0	Sandag 1996
Warehouse	Industrial	90	5	5	Sandag 1996
General Light Industry	Industrial	80	20	0	Sandag 1996
General Heavy Industry	Industrial	90	5	5	Sandag 1996
Industrial Park	Industrial	80	20	0	Sandag 1996
Manufacturing	Industrial	90	5	5	Sandag 1996

III.6 Construction Emissions

III.6.1 Specifying Construction Emissions

Main Construction Screen: Overall Construction Settings. Figure 7 shows the introductory or main construction emissions screen. Please note that the screen or window is divided into two panes, the left pane and the right pane. A splitter bar separates the left and right panes. By placing the cursor on the splitter bar and dragging right or left with the mouse, the relative size of each pane can be changed. This allows the user to see text that may be partially hidden. The cursor can also be placed on the edges of the window and dragged to make the entire window larger or smaller. The left pane contains a list, with each item on that list called a node.

The construction emissions portion of URBEMIS2002 has been substantially modified from previous versions. URBEMIS2002 allows the user to specify information for three construction phases that are typical for most projects. Those phases include demolition, site grading, and building construction. URBEMIS assumes that these three phases cannot overlap and that demolition occurs first, followed by site grading, then finishing with building construction.

For the construction screen, each of the nodes in the left pane represents one of the three construction phase categories or construction types. The three subphases associated with Phase 3 are also shown, along with the mitigation measure button. When the cursor is placed on one of the categories or nodes in the left pane and clicked, information associated with that category is shown in the right pane.

The main construction screen requires that the user specify the project start year, the start month, the construction period (in months), and the number of construction days per month (see Figure 7). (In this version of URBEMIS2002, the user cannot edit the number of construction days per month.) URBEMIS2002 calculates default phase lengths (months) for each of the three phases. Those calculations assume that Phase 1 consists of 5 percent of the total construction period, Phase 2 consists of 10 percent, and Phase 3 consists of 85 percent. The user can either agree to use the URBEMIS default phase lengths or can enter project specific phase lengths. The user also has the option of turning off a phase if it is not applicable to the project. For example, many land use development projects do not include demolition; consequently, Phase 1 would need to be turned off for those projects. Whenever a phase is turned off by the user, URBEMIS recalculates the default phase lengths for those phases that remain turned on.

Phase 3, building construction, consists of up to three subphases: building construction, application of architectural coatings, and asphalt laying. Either of these three subphases of Phase 3 can be turned off by the user. Unlike the three phases, the subphases can occur either sequentially or with partial or complete overlap. URBEMIS automatically calculates the start month and duration of each subphase, which also can be overridden by the user. As a worst case, URBEMIS assumes that the three subphases will overlap. Unless overridden, URBEMIS2002 automatically assumes that the building construction subphase will begin immediately after Phase 2 has ended and will continue until the end of Phase 3. URBEMIS2002 also assumes that paint application and asphalt laying will overlap with building construction. Since the paint and asphalt subphases generally do not last as long as building construction, they are assumed to overlap at the back end of Phase 3 (see Figure7) unless overridden by the user.

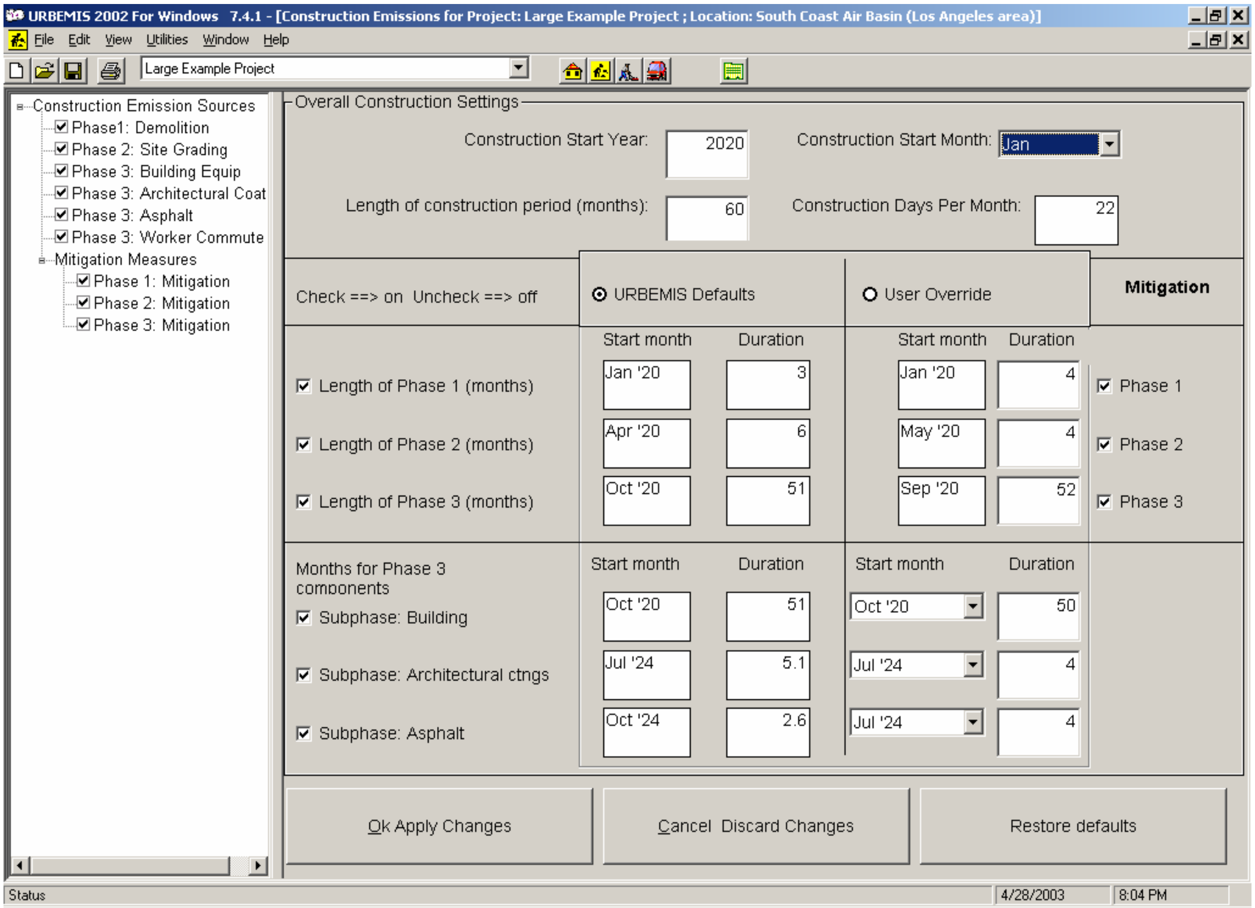

Figure 7. Construction Emissions Main Screen

Phase 1 - Demolition

From the construction emissions main screen (see Figure 7), demolition emissions can be specified by clicking on the Length of Phase 1 checkbox in the right pane. Clicking the OK-Apply Changes button saves that information. Then to enter specific demolition information, you must click on the Phase 1 – Demolition node found in the left pane. By doing so, you are taken to the first of four demolition screens (Figure 8). Those four screens are as follows:

Phase 1 – Demolition Dust and On-Road Emissions Settings
Phase 1 – Demolition Equipment Exhaust 1
Phase 1 – Demolition Equipment Exhaust 2
Phase 1 – Demolition Equipment Exhaust 3

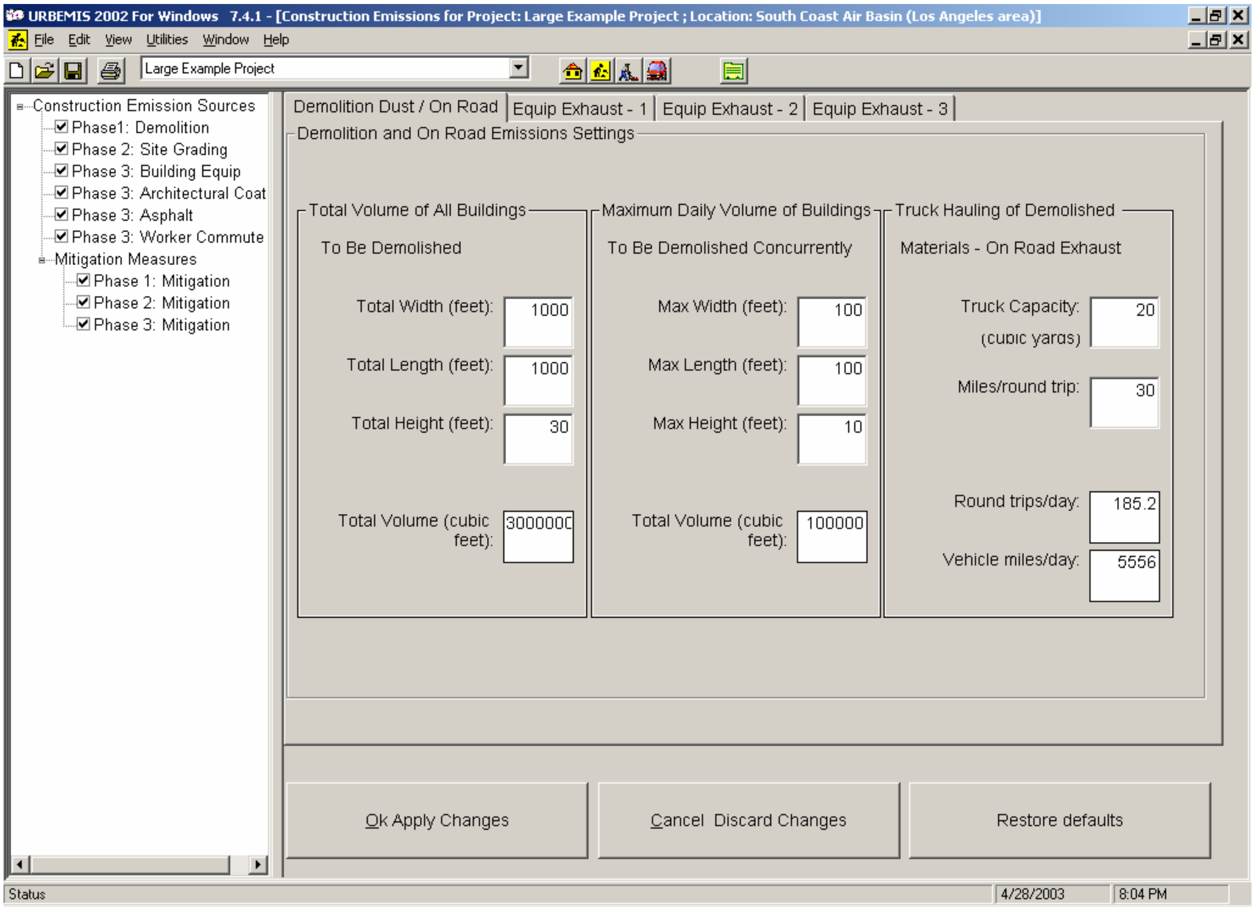

Figure 8. Phase 1 – Demolition Dust and On-Road Emissions Settings

You can switch between these four screens by clicking on the tabs found at the top of the right pane. The first of these four screens – Demolition Dust and On-Road Emissions Settings – allows the user to enter the total volume of material to be demolished and the maximum daily volume of material slated for demolition. URBEMIS uses the maximum daily volume of material to estimate the on-road vehicle miles traveled per day needed to haul the demolished material to its ultimate destination. The program assumes a default truck capacity of 20 cubic yards (of demolished material) and a round trip haul distance of 30 miles. Both of these values can be overridden by the user. Changing default truck capacity and round trip haul distance also changes the total on-road VMT per day estimates.

The three remaining demolition screens are used to specify the number and type of off-road equipment that will be used during the demolition activities. The user must enter the number of each type of equipment that will be used for demolition and, if necessary, modify the horsepower, load factor, and hours per day that the equipment would operate.

Phase 2 – Site Grading

By clicking on Phase 2 – Site Grading in the left pane of the construction screen, URBEMIS displays the first of six screens (Daily Acreage) in the right pane (Figure 9). The user can go back and forth between these six screens by clicking on the tabs at the top of the right pane. Those six screens include:

1) Daily Acreage
2) Fugitive Dust
3) Soil Hauling
4) Equipment Exhaust – 1
5) Equipment Exhaust –2
6) Equipment Exhaust – 3

The Daily Acreage screen contains an important summary of the land use information for the project, including the number of single family and multi-family units and the total square footage of the non-residential projects (see Figure 9). Each time land uses are modified, URBEMIS will not modify the number of single and multi-family units and total square footage until the user hits the Recalc with Land Uses button. By hitting that button, URBEMIS recalculates the values in the Daily Acreage screen so that the residential units, building square footage, and acreage values are consistent with the land use values. The total acreage and maximum acreage disturbed per day values at the bottom of this screen are estimates generated by URBEMIS that can be overridden by the user. These total values are important because URBEMIS will, if requested, use them to calculate values in other parts of URBEMIS, including the number of construction vehicles used in site grading and in building equipment.

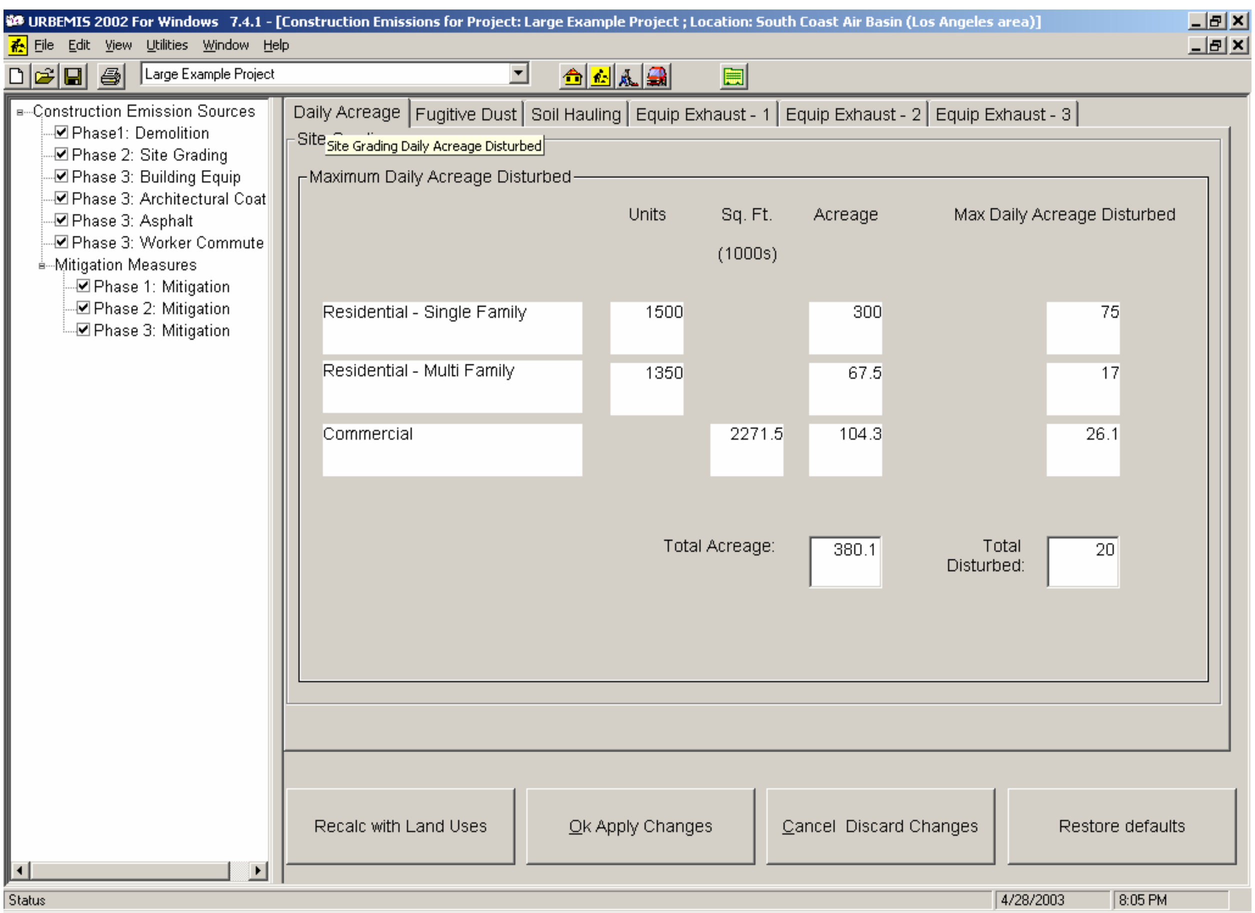

Figure 9. Daily Acreage

Clicking on the second tab – Fugitive Dust – takes the user to the next screen (Figure 10). The user is provided with the option of selecting one of four fugitive dust emission levels with the Default

Level requiring the least information and the High Level requiring the most detailed information. Each level requires increasingly more detailed information about project construction. If the Low, Medium, or High levels are selected, additional information must be entered by the user. If the Default Level is selected, no additional information need be entered, though the user has the option of modifying the default fugitive dust emission rate. The Default Level represents the approach used to estimate fugitive dust in URBEMIS2001. To estimate fugitive dust emissions, URBEMIS estimates emissions in the Default Level by multiplying the default emission rate by the maximum acreage disturbed per day (from the previous acreage screen).

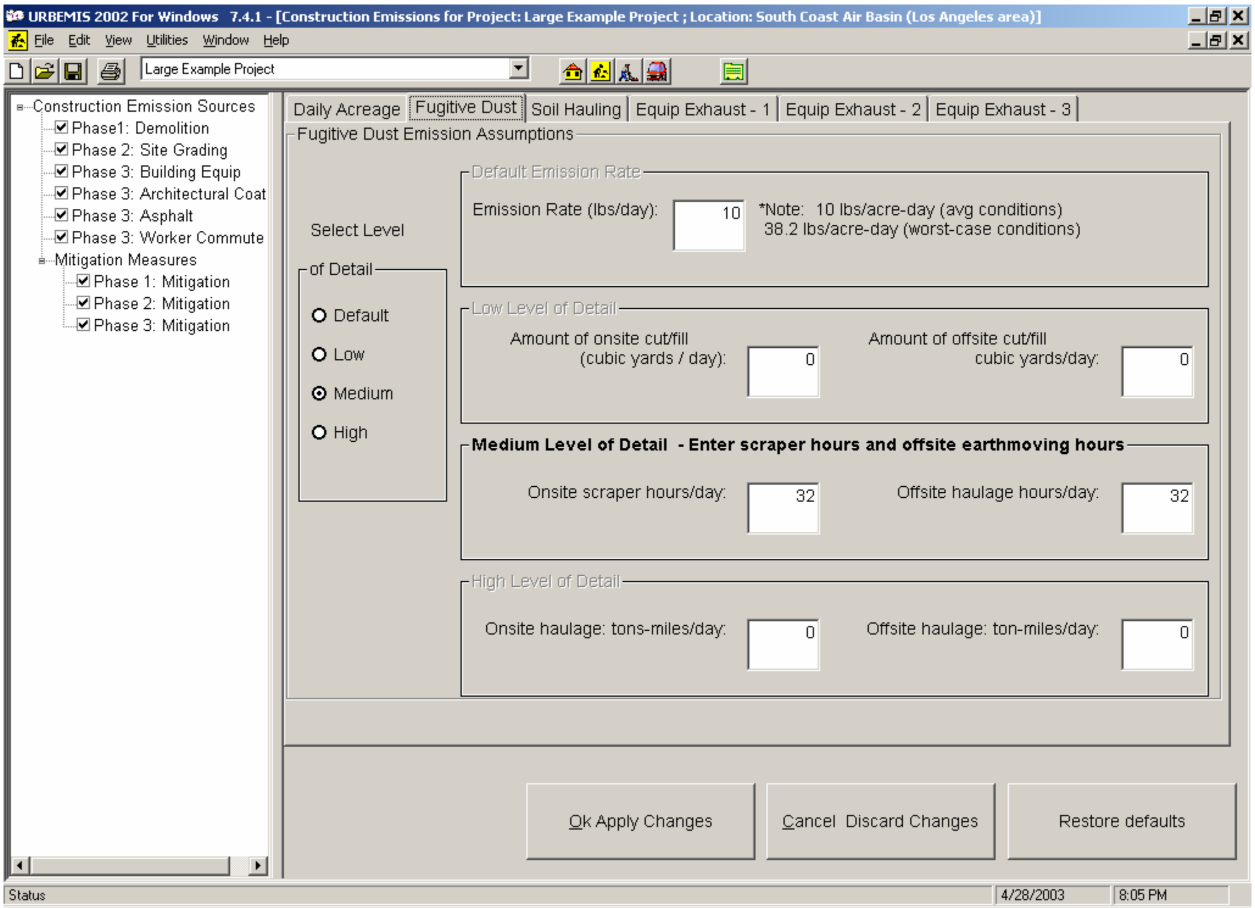

Figure 10. Phase 2 – Fugitive Dust

The third tab – soil hauling – is used to estimate on-road vehicle emissions associated with site grading (see Figure 11). The user must enter the amount of soil to be imported to and/or exported from the site. The user can also modify the average truck hauling capacity (20 cubic yards) and the truck haul round trip distance (20 miles).

The fourth, fifth, and sixth tabs represent the off-road construction vehicles that can be selected for the site grading phase. The user has the option of selecting the type and number of vehicles applicable to the project, and can modify the vehicle horsepower, load factor, and hours per day for either of the vehicle types. Also, the user can tell URBEMIS to estimate the number and type of vehicles appropriate for a project of the size specified by the user. To do that, you must hit the Recalc with Land Uses button. URBEMIS will replace any information entered by the user with the values it calculates.

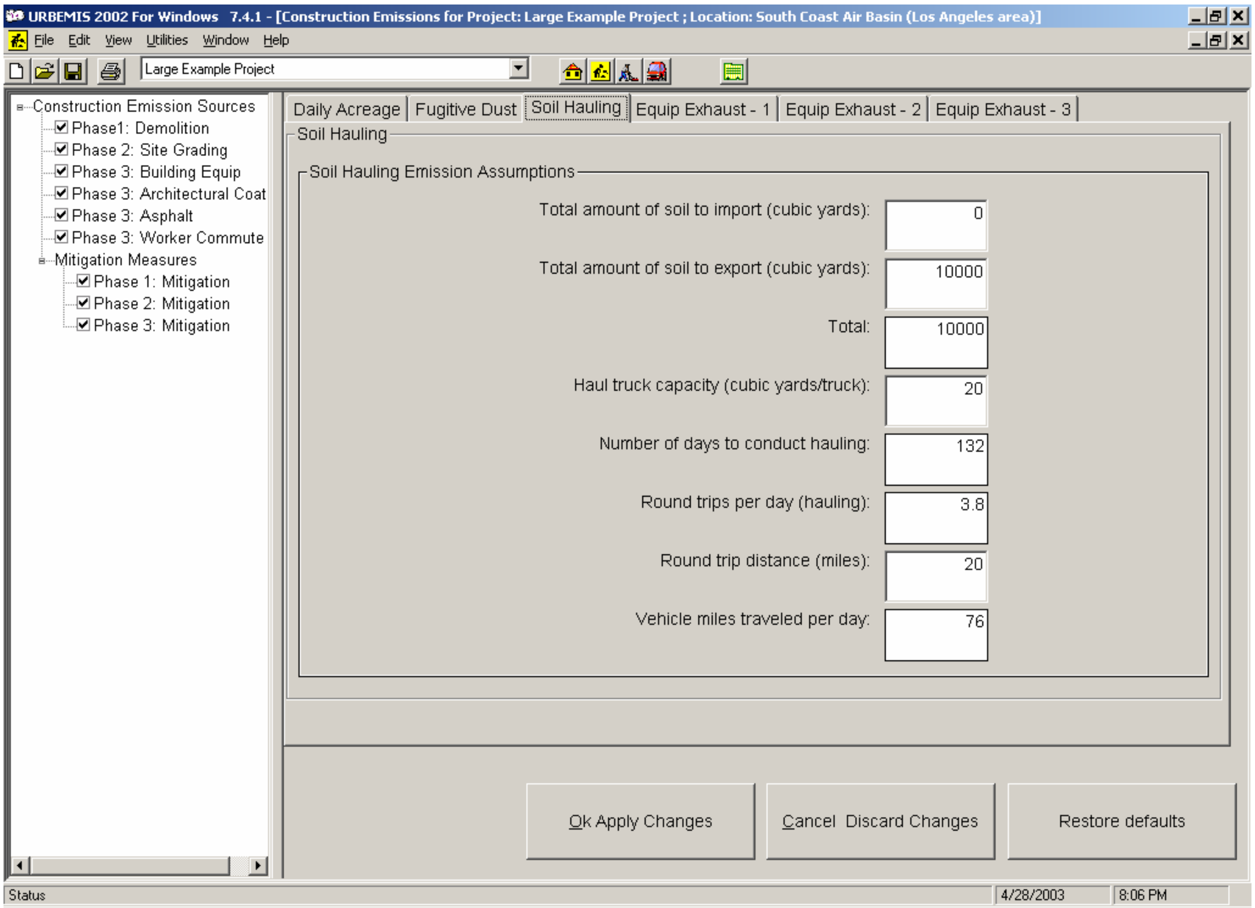

Figure 11. Phase 2 – Soil Hauling

Phase 3 – Building Construction

Phase 3 is treated slightly differently than Phases 1 and 2. When you are working in the URBEMIS2002 construction module, the left pane of that module includes one node for Phase 1, one node for Phase 2, but four nodes for Phase 3 (see Figure 7 above). By clicking on the first of these four nodes – Building Equipment – URBEMIS displays the first of three equipment exhaust screens in the right pane. You can go back and forth between the three equipment exhaust screens by clicking on the tabs at the top of the right pane. Within these three screens, you should enter the number of each type of off-road construction equipment that will be used during the Phase 3 building construction subphase of the project. You should also edit the horsepower, load factor, and hours per day if that level of detail is available for the project. If construction equipment numbers are unavailable, then you can hit the Recalc with Land Uses button, which will prompt URBEMIS to enter its estimate of the default number of vehicles based on the land uses that have been entered.

The second of the four Phase 3 nodes in the left pane is Architectural Coatings. By clicking on that node, URBEMIS displays in the right pane the residential and nonresidential assumptions used to estimate architectural coatings. All of the displayed assumptions can be modified by the user.

The third of the four Phase 3 nodes in the left pane is Asphalt. By clicking on that node, URBEMIS displays the first of four screens in the right pane. Those four screens include: Off-Gas Emissions and Equipment Exhaust 1, 2, and 3. The user can navigate between the four screens by clicking on the tabs found at the top of the right pane. The Off-Gas Emissions screen shows the acres to be paved and the ROG off-gas emission rate in pounds per acre. The information in this screen is used to estimate total off-gas emissions from asphalt used in paving the site. The user should enter the total acres to be paved, if known. If that value is unknown, then URBEMIS will calculate a value based on entered land uses when the user clicks on the Recalc with Land Uses button.

In addition to the Off-Gas Emissions screen are the three equipment exhaust screens. You can go back and forth between the three equipment exhaust screens by clicking on the tabs at the top of the right pane. Within these three screens, you should enter the number of each type of asphalt construction equipment that will be used during the Phase 3 asphalt paving subphase of the project. You should also edit the horsepower, load factor, and hours per day if that level of detail is available for the project. If asphalt construction equipment numbers are unavailable, then you can hit the Recalc with Land Uses button, which will prompt URBEMIS to generate its own estimate of the type and number of vehicles based on the land uses that have been entered.

The fourth of the four Phase 3 nodes in the left pane is Worker (Commute Trips). By clicking on the Worker node in the left pane, URBEMIS displays the construction worker trip generation rates that it uses to calculate worker trips and associated emissions. URBEMIS displays those trip generate rates in the right pane. Those trip rates can be edited by the user.

III.6.2 Specifying Construction-Related Mitigation Measures

To specify construction mitigation, you must first check one, two, or all three construction mitigation boxes found on the right side of the construction main screen (see Figure 7). You should be aware that you cannot turn on a construction mitigation phase unless you have also turned on that phase by checking the phase box. For example, you cannot turn on the demolition mitigation box unless you have already turned on Phase 1 demolition. And, once you have turned on one or more of the three mitigation phases, they will not be saved until you hit the OK-Apply Changes button at the bottom of the screen. Once you have hit the OK-Apply Changes button, however, the boxes in the left pane of the screen are made consistent with those on the right pane of the construction start screen. Then, to specify mitigation measures applicable to a project, you must first click on one of the boxes in the left pane of the construction screen.

By clicking on the Phase 1- Mitigation node in the left pane, you are taken to the first of four screens from which demolition related mitigation measures can be selected (see Figure 12).

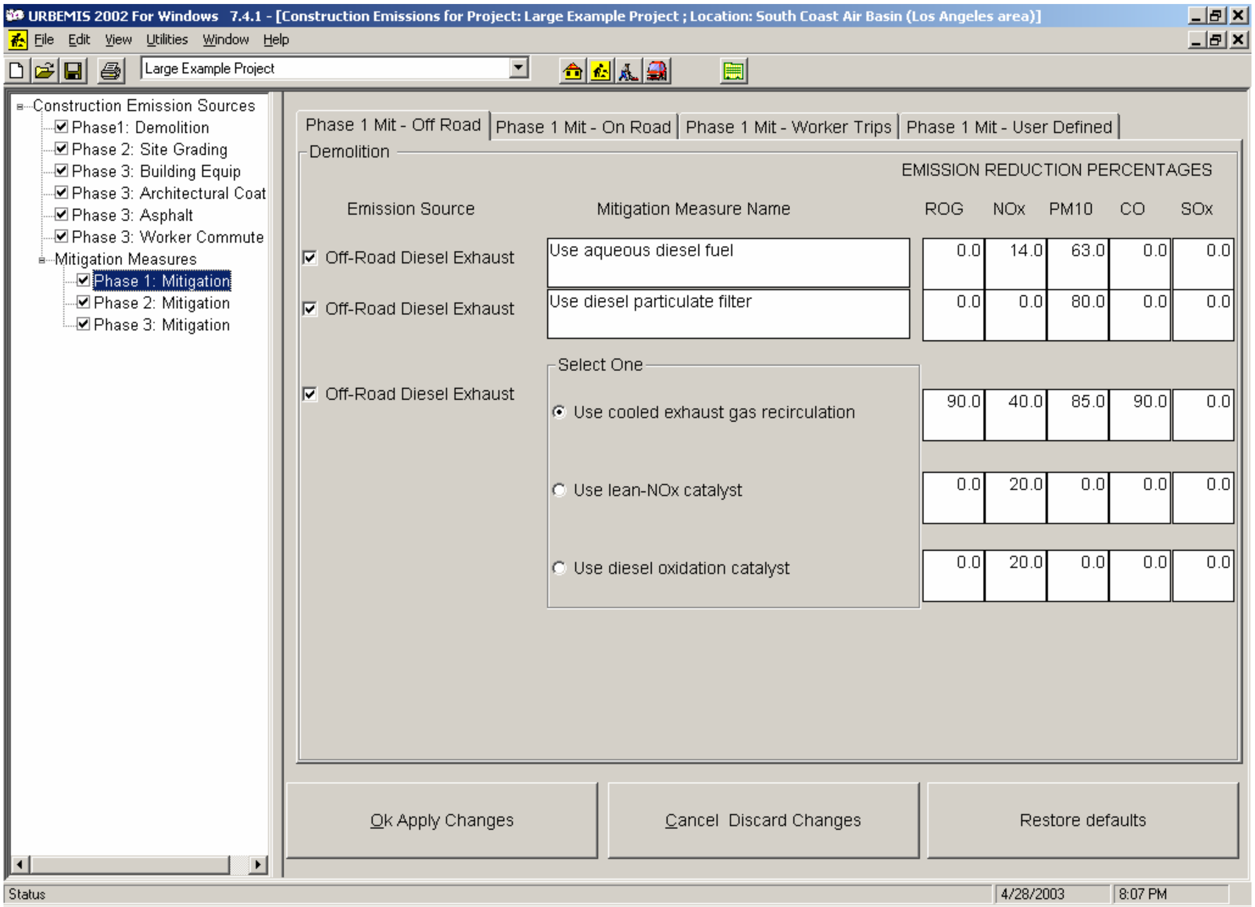

Figure 12. Phase 1 - Mitigation for Off-Road Diesel Exhaust

Those four screens, which can be selected by clicking on the tabs, include the following:

Phase 1 Mitigation for Off Road Diesel Exhaust
Phase 1 Mitigation for On Road Diesel Exhaust
Phase 1 Mitigation for Worker Commute Trip Emissions
Phase 1 Mitigation – User Defined Options

From the first three of these four screens, the user can select pre-defined mitigation measures that are applicable to the project being analyzed. Each of these pre-defined measures includes specific emission reduction efficiencies. The fourth screen allows the user to specify additional mitigation measures and control efficiencies.

Construction mitigation measures for Phase 2 – Site Grading works similarly to the Phase 1 mitigation measure. By clicking on Phase 2- Mitigation (left part of construction screen), you are taken to the first of five screens from which site grading related mitigation measures can be selected. Those five screens, each of which can be selected by clicking on the tabs, include the following:

Phase 2 Mitigation for Soil Disturbance
Phase 2 Mitigation for Off Road Diesel Exhaust
Phase 2 Mitigation for On Road Diesel Exhaust
Phase 2 Mitigation for Other Emission Sources
Phase 2 Mitigation – User Defined Options

For the first four of these five screens, the user can select pre-defined mitigation measures that are applicable to the project being analyzed. Each of these pre-defined measures includes specific emission reduction efficiencies. The fifth screen allows the user to specify additional mitigation measures and control efficiencies.

Construction mitigation measures for Phase 3 – Building Construction works similarly to the Phase 1 and 2 mitigation measures. By clicking on Phase 3- Mitigation (left pane of construction screen), you are taken to the first of five screens from which building construction related mitigation measures can be selected. Those five screens, each of which can be selected by clicking on the tabs, include:

Phase 3 Mitigation for Off Road Diesel Exhaust from Building Construction
Phase 3 Mitigation for Off Road Diesel Exhaust from Asphalt Paving
Phase 3 Mitigation for On Road Diesel Exhaust
Phase 3 Mitigation for Worker Commute Trips
Phase 3 Mitigation – User Defined Options

For the first four of these five screens, the user can select pre-defined mitigation measures that are applicable to the project being analyzed. Each of these pre-defined measures includes specific emission reduction efficiencies. The fifth screen allows the user to specify additional mitigation measures and control efficiencies.

III.7 Area Source Emissions

III.7.1 Specifying Area Emissions

The "Area-Source Emission" screen allows you to estimate area-source emissions for up to five categories of emission sources. Four of these five categories are fuel combustion related: natural gas, wood stoves, fireplaces, and landscape maintenance. The fifth, consumer products, includes only reactive organic compound emissions released through the use of products such as hair sprays and deodorants. The emission factors used by URBEMIS2002 to estimate area-source emissions are described in detail in Appendix B.

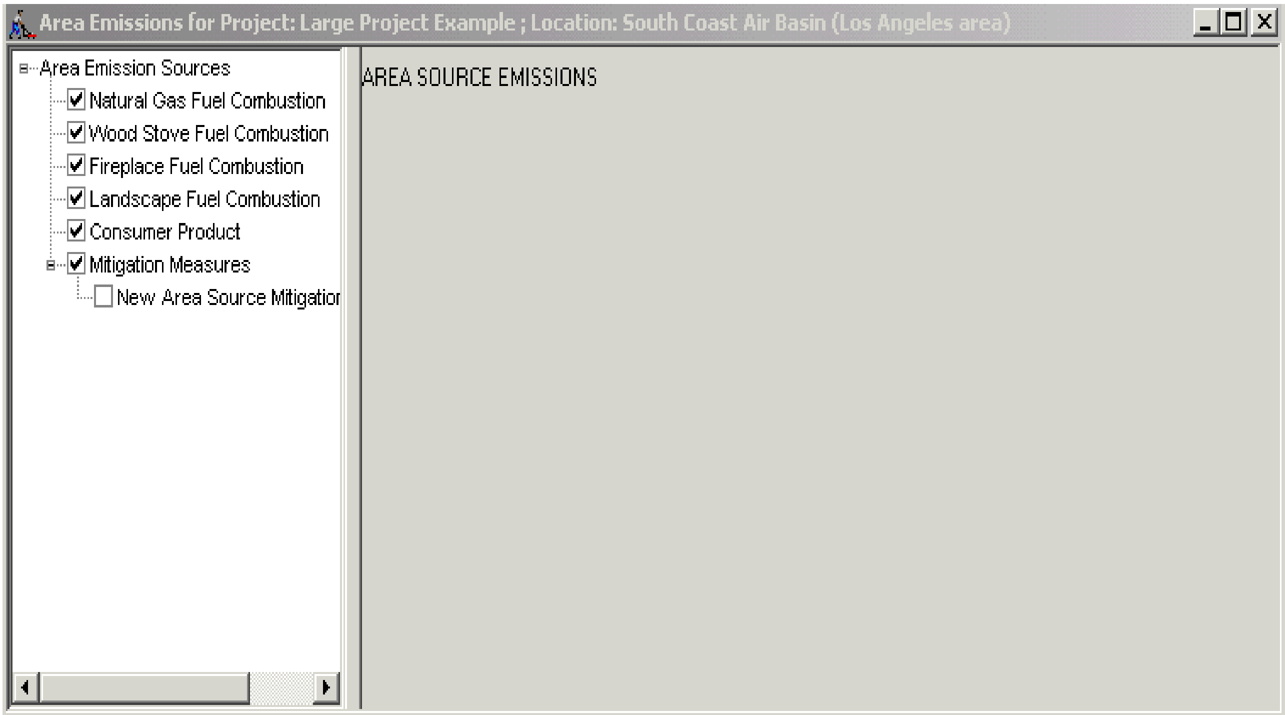

Figure 13. Area Source Entry Screen

Figure 13 shows the introductory area source emissions screen. Please note that the screen or window is divided into two panes, the left pane and the right pane. A splitter bar separates the left and right panes. By placing the cursor on the splitter bar and dragging right or left with the mouse, the relative size of each pane can be changed. This allows the user to see text that may be partially hidden. The cursor can also be placed on the edges of the window and dragged to make the entire window larger or smaller. The left pane contains a list, with each item on that list called a node.

Each of these five area source categories is shown in the list of the left pane. Information associated with each category is shown in the right pane. To examine the information associated with an item in the list, move the cursor to the item in the list shown in the left pane and click on that item. Information associated with that item is then displayed in the right pane. Although you can use this procedure to examine information in the right pane, the user must check the box associated with each of the categories for which emission estimates are desired.

When you click on the “Natural Gas Fuel Combustion” settings button in the left pane list, the right pane changes to show you the “Natural Gas Combustion Settings” default information. You may then modify any of the settings, which will be saved by clicking on the “OK-Apply Changes” button. A similar procedure can be used to review or modify the settings for each of the area emission sources. The user should note, however, that clicking the “OK-Apply Changes” button save the information to memory, but not to a file. To save information to a file, see section III.11.

Note that the setting for fuel combustion-landscape maintenance requires you to enter the year being analyzed. This year does not have to match the year entered for construction or motor vehicle emissions.

III.7.2 Specifying Area-Source Mitigation Measures

From the "Area Source" main menu, you may select area-source mitigation measures by clicking the "Mitigation Measures" checkbox in the left pane list. This action forces URBEMIS2002 to display the preprogrammed area source mitigation measures in the right pane. The user can select a number of preprogrammed area-source mitigation measures for residential, commercial, and industrial sources. The efficiencies of the preprogrammed area source mitigation measures are shown in Table 4.

You can also add up to 10 additional area-source mitigation measures by selecting "New Area Source Mitigation Measures" from the left pane list. You are then shown the "Additional Area-Source Mitigation Measures" in the right pane, where you are required to enter, for each measure that you want to add, the measure name, measure type, and percentage emission reduction for ROG, NOx, PM10, and CO. The measure type is limited to one of seven types: residential space heating, residential water heating, residential landscape maintenance, commercial space heating, commercial water heating, commercial landscape maintenance, and industrial space heating.

Table 4. Area Source Emissions Mitigation Measures

Emission Source	Mitigation Measure	Emission Reduction (%) ROG	NOx	PM10	CO	Source
Residential Water Heaters	Use solar or low-emission water heaters	11	9.5	4.5	10	(SCAQMD 1993)
Residential Water Heaters	Use central water heating systems	9	8	4	8.5	(SCAQMD 1993)
Residential Heating	Orient buildings to the north for natural cooling and heating	14	13	10.5	13.5	(SCAQMD 1993)
Residential Heating	Increase walls and attic insulation beyond Title 24 requirements	14	13	7.4	13	(SCAQMD 1993)
Commercial Water Heaters	Use solar or low-emission water heaters	0.5	0.5	0.5	0.5	(SCAQMD 1993)
Commercial Water Heaters	Use central water heating systems	0.5	0.5	0.5	0.5	(SCAQMD 1993)
Commercial Heating	Orient buildings to the north for natural cooling and heating	11	13.5	17.5	12.5	(SCAQMD 1993)
Commercial Heating	Increase walls and attic insulation beyond Title 24 requirements	10	9	7	9.5	(SCAQMD 1993)
Industrial Heating	Orient buildings to the north for natural cooling and heating	2	3	2.5	5.5	(SCAQMD 1993)
Landscape Maintenance - Residential	Project provides electric maintenance equipment	100	100	100	100	(no reference)
Landscape Maintenance - Commercial	Project provides electric maintenance equipment	100	100	100	100	(no reference)

III.8 Vehicle or Operational Emissions

III.8.1 Specifying Vehicle Emissions

The "Settings for Operational-Related Emissions" entry screen in shown in Figure14. Please note that the screen or window is divided into two panes, the left pane and the right pane. A splitter bar separates the left and right panes. By placing the cursor on the splitter bar and dragging right or left with the mouse, the relative size of each pane can be changed. This allows the user to see text that may be partially hidden. The cursor can also be placed on the edges of the window and dragged to make the entire window larger or smaller. The left pane contains a list, with each item on that list called a node.

The left pane of Figure 14 shows eight separate nodes in the list (excluding the mitigation check boxes). Each node represents information needed to estimate motor vehicle emissions. The first five of these nodes (vehicle fleet percentages, target year, trip characteristics, temperature data, variable starts, and road dust) must be checked (they cannot be unchecked) to obtain motor vehicle emissions. The remaining three nodes (road dust, pass-by trips, and double counting) are optional and do not have to be checked to obtain motor vehicle emission estimates. The double counting node does not appear unless the user has indicated a mixed use project by entering both a residential and a non-residential land use in the land use selection screens.

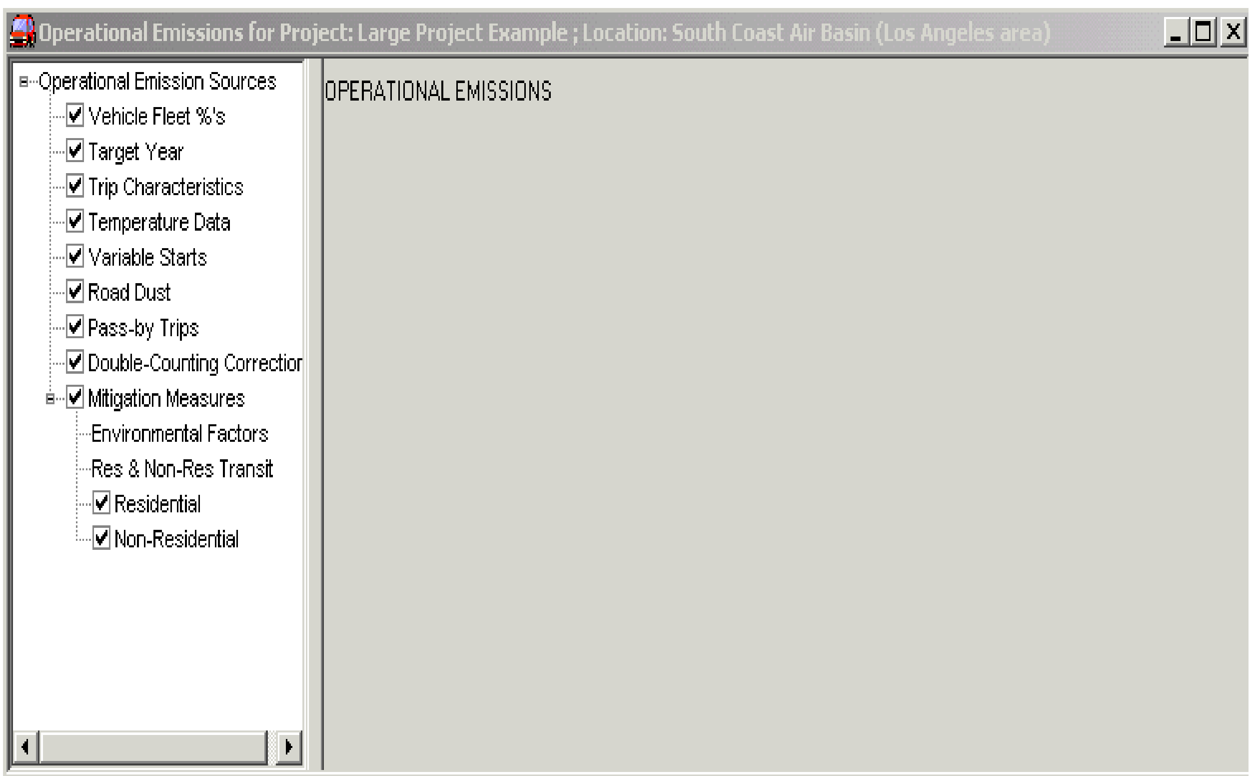

Figure 14. Operational Emissions Entry Screen

Each of the operational vehicle categories is shown as a node in the left pane list. Information corresponding to each node can be accessed by placing the cursor on the node and clicking. This forces URBEMIS2002 to display the associated information in the right pane

Note that neither the "Settings for Operational-Related Emissions" screen nor any of its supporting screens allow you to specify the season (winter or summer) for which you want to estimate emissions. URBEMIS2002 automatically estimates motor vehicle emissions for both winter and summer of the target year using the temperature data specified in the temperature data screen. You are given the option of viewing or printing either summer or winter emission estimates in the output screens (see discussion under Section III.9).

Vehicle Fleet Percentages. The vehicle fleet percentages can be selected by clicking on the vehicle fleet percentages node in the left pane. This action displays "Vehicle Fleet Characteristics -1" in the right pane. This right pane also includes a second tab, "Vehicle Fleet Characteristics – 2". URBEMIS2002 includes 13 vehicle types. And for each vehicle type, there are three fuel/technology classes: non-catalyst (gasoline), catalyst (gasoline), and diesel. Within the right pane, you can modify any of the fleet percentages or fuel/technology classes. The total fleet percentage must total to 100. Also, for each vehicle type, the three fuel/technology classes must subtotal to 100 percent. Once you are satisfied with the information, you can save it to memory by hitting the "OK Apply Changes" button.

Target Year. The target year can be modified by clicking on the "Target Year Settings" box in the left pane list, which then shows you the "Target Year" screen in the right pane. You should click on the year for which you would like to estimate emissions. Once you have selected the correct year, you can save it to memory by hitting the "OK Apply Changes" button.

Trip Characteristics. The "Trip Characteristics" screen can be modified by clicking on the "Trip Characteristics Settings" node in the left pane. This action displays the trip characteristics in the right pane. Several pieces of information are contained in the "Trip Characteristics" screen: average trip speeds, trip percentages, and trip lengths for five different trip types (home-based work trips, home-based shopping trips, home-based other trips, work trips, and commercial-based non-work trips).

Note that the "Trip Characteristics" screen allows you to enter the trip percentages for home-based trips, which must total 100 percent. However, this same screen does not permit you to enter trip percentages for commercial-based trips. Instead, commercial-based percentages are calculated separately by URBEMIS2002 for each nonresidential land use selected in the "Land Use" screens (see Section III.5).

The "% Worker Commute" information from the land use screens corresponds to the commercial-based commute work trip value. The commercial-based commute trip percentage is then used to estimate commercial-based non commute work trip and customer based trip percentages for each land use. If the commercial-based commute trip value exceeds 50 percent, then the commercial-based non commute trip percentage equals 100 percent minus the commute trip percentage, multiplied by 50 percent. If the commercial-based commute trip value is less than 50 percent, then the commercial-based non commute trip percentage equals one half of the commercial-based commute trip value. Finally, for each land use, customer based trips are assumed to equal the 100 percent minus the total of the commercial commute and non commute percentages.

The "Trip Characteristics" screen also allows you to modify default percentages for urban and rural trip lengths by trip type. The initial URBEMIS2002 screen used to open an existing or new project contains a checkbox that allows the user to identify the project as being located in an urban or a rural setting. If you have identified the project as urban, then the urban trip lengths are used to estimate vehicle miles traveled and, ultimately, emissions. In contrast, if you have identified the project as rural, then the rural trip lengths are used. Once you have selected the correct year, you can save it to memory by hitting the "OK Apply Changes" button.

Temperature Data. By clicking on the temperature data in the left pane, temperature options are presented in the right pane. You have the option of modifying both winter and summer ambient temperatures, which are used to estimate winter and summer emission estimates and which correspond to the summer versus winter gasoline specifications used in California outside of the South Coast Air Basin (greater Los Angeles). Selecting "OK Apply Changes" from the "Temperature Data" screen saves the information to memory.

Variable Starts. You may modify the "Variable Starts" information by clicking on the "Variable Starts" settings button shown in the left pane. This action causes URBEMIS2002 to display variable starts information in the right pane. That screen includes information on "Variable Start Percentages by Trip Type and Time since Engine Stopped". EMFAC2002 requires the vehicle engine shut-off percentages for 18 time increments, ranging from 5 minutes to 720 minutes. The information provided in this screen by trip type represents statewide averages of pre-start cool-down profiles from an ARB analysis of the 1991 California Department of Transportation household travel survey. These percentages should not be modified unless better information is available. Selecting "OK Apply Changes" from the "Temperature Data" screen saves the information to memory.

Road Dust. You may turn the Road Dust option on or off by clicking the check box in the left pane. This action will also display in the right pane information on "Entrained Road Dust Emissions". You have the option to modify the distribution of travel between paved and unpaved roads. You also have the option to modify the paved road or unpaved road defaults by clicking on the accompanying tabs.

If you click on the "Change Paved Road Defaults..." tab, you are taken to the "Paved Road Dust Emissions" screen. From within that screen, you may modify the default emission factors and percentage of travel for each of four road types.

You may also click on the "Change Unpaved Road Defaults" tab, where URBEMIS2002 will display the "Unpaved Road Dust Emissions" screen. From this screen, you can select either the U.S. EPA methodology for calculating emissions or you can use the California Air Resources Board's emission factor. If you select the U.S. EPA methodology, you are allowed to modify one or more of the five variables used to estimate unpaved road dust emissions.

Double Counting. Another option available to URBEMIS2002 users is to adjust for double-counting.. The double-counting adjustment is designed to reduce double counting of internal trips between residential and nonresidential land uses. Consequently, selecting this option is available only when you have selected both residential and nonresidential land uses. You must click the check box in the left pane where URBEMIS2002 displays the "Double Counting Correction". URBEMIS2002 then displays in the right pane a screen that asks which of two methods you would like to use to adjust for double counting: direct input of the number of internal trips or program-generated estimate of internal trips.

If you select the first option – "Direct Input of the % of Total Trips - use must click the corresponding tab, which takes you to the "Direct Input Double Counting Adjustment" screen. At this screen, you are shown the number of residential and nonresidential trips that would be generated based on the land uses selected. You are given the option of entering the number of internal trips between residential and nonresidential land uses. The value entered represents the number of internal trips that will not be included in the emissions estimate. Once you are comfortable with the internal trip estimate, clicking on the “OK/Return” button returns to the “Settings for Operational-Related Emissions” screen.

If you select the second option, “Program-Generated Estimate of Internal Trips”, from the “Double Counting Adjustment” screen, then URBEMIS2002 presents the “Urbanized Context” screen. You must then identify how the proposed project fits into its urbanized context. This information is used to provide suggested default percentages. Once you have entered the desired percentages, then clicking on the “OK – Apply Changes” button saves the information to memory.

Pass-by Trips. You may select the “Pass-By Trips” button from the left pane list. When you select “Pass-By Trips”, no optional information is presented in the right pane. Selecting the “Pass-By Trips” button allows URBEMIS2002 to calculate emissions from vehicle trips that are generally lower than estimates without the pass-by trip option. The pass-by trip algorithm is described in Appendix C.

III.8.2 Specifying Vehicle-Related Mitigation Measures

From the Operational Emissions” screen, you have the option of turning operational mitigation measures on or off by clicking on the “Mitigation Measures” box in the left pane. If you opt to estimate mitigated emissions, you can select and edit any of four operational mitigation measure screens by clicking it in the left pane list. Those four options include:

- environmental factors;
- regional and nonregional transit;
- residential; and
- non-residential

Each of these is described below:

The user may select to use either default environmental conditions and transit service or to go through the list of environmental factors for pedestrian environment, transit service, and bicycle environment. The defaults are set at a level achievable by a standard suburban automobile oriented subdivision or commercial development.

Once the user has selected the environmental conditions applicable to his or her project, the next step involves selecting appropriate mitigation measures. Those measures include residential, non-residential, and transit mitigation measures, which applies to both residential and nonresidential land uses. The user should select all mitigation measures that are appropriate for the project from the groups of measures that are listed. They include measures to decrease single occupant motor vehicle trips including transit measures, bicycle measures, commute trip measures, etc.

The program adds the reductions from each category of measure and reduces the total based on the environmental factors and presents this quantity in the final report. The program will add all reductions by measure types (transit, pedestrian, bike, and other). The program then adjusts the amount by a correction factor to account for differences in effectiveness for different types of trips (H-W, H-S, H-O, W, N-W emp, N-W customer). A second correction factor adjusts the pedestrian and bicycle reductions to account for the shorter trips being replaced by these modes.

The program takes the adjusted trip reduction percentages and reduces the trips generated by the URBEMIS trip generation component. The new, lower trip generation rate is then multiplied by the emission factors to calculate emissions. The program will multiply VMT reduced by the running emission factor and then subtract the amount from total emissions.

The program generates a report listing the environmental and transit service factors selected, mitigation measures selected, percent reductions for each mitigation type, and percent reduction for each trip type. The final results will provide unmitigated project emissions, amount mitigated, and mitigated project emissions.

The Vehicle-Related Mitigation Measures component allows you to calculate emission reductions achieved by applying mitigation measures to a project. In order to account for the variability in effectiveness of mitigation measures due to environmental conditions, the program requires you to set environmental factors that affect the measures. The percent reduction listed on the screen for each measure represents the maximum achievable under ideal conditions. The environmental factors reduce this amount in an internal calculation to arrive at the actual percent reduction.

The first screen you will encounter is the "Set Travel Mode Environment Screen." This screen allows you to select either a default environment or to set the environment using a series of screens describing the conditions affecting travel in and around the project site. The default environment is based on an automobile oriented suburban area with no transit service. If you select the default environment you are then taken to the mitigation measure selection screens, which will be described later. If you select the set environment option you are taken to the "Pedestrian Environment Factor" screen.

From the "Pedestrian Environment Factor" screens you must select from three levels of coverage for seven different factors affecting pedestrian travel. Guidance for determining the level of coverage for each factor is provided in the Mitigation Handbook. After you have selected a level for each factor, the program adds the points selected and then divides this number by the total points possible to arrive at the Pedestrian Environment Factor (PEF). The program then takes you to the "Transit Environment Factor" screen.

From the "Transit Environment Factor" screen you must select the highest level of transit service serving the project site. In some cases, this may be the planned level of service as indicated in an approved transit plan. Once you have selected the level of transit service, you are taken to the "Bicycle Environment Factor" screen.

The "Bicycle Environment Factor" screens are similar to the PEF screens. You must select from three possible levels of coverage corresponding basically to high, medium, or low for each of six different factors. Once you have completed these screens, you are taken to the mitigation measure selection screens.

The first mitigation measure selection screen is "Transit Enhancing Infrastructure Measures." The screen is divided into two sections, Project Description Items and Developer Measures. Project Description Items are items that provide a benefit just because of the projects location or design. Developer Measures are physical improvements and infrastructure provided or funded by the developer. These are the more traditional mitigation measures. The first possible selection is for the Project Description Item "Project Density Meets Transit Level of Service Requirement." This may be determined by comparing the current or planned level of transit service with the numbers in Appendix D, Table D-3 and D-4. Next, select each Developer Measure that will be applied to the project. The program allows the program user to include other mitigation measures not listed, however the total percent reduction allowed may not exceed the predetermined maximum shown on the screen.

The next mitigation measure selection screen is “Pedestrian Enhancing Infrastructure Measures (Residential).” If you selected both residential and non-residential land uses on the first screen, you will see separate screens for residential and non-residential mitigation measures for enhancing pedestrian travel. The first user selection is a credit for “Mixed Use Project (Residential Oriented)” in the Project Description Items section. A definition of “Mixed Use” can be found in the Mitigation Handbook. Next you must select the Developer Measures that will be applied to the project from those listed or you may add new measures.

The “Pedestrian Enhancing Infrastructure (Non-Residential)” screen includes Project Description Items for Mixed Use Project (Commercial) and for Floor Area Ratio (FAR) .75 or greater. Select Project Description Measures and Developer Measures or add measures as with the previous screens.

The “Bicycle Enhancing Infrastructure Measures” screens are next. No user selected Project Description Measures are provided. Select developer measures or add new measures as with the previous screens.

The next set of screens cover Operational Measures. These are measures that an employer or building owner would implement to reduce trips. The first set of measures apply to employee commute trips. The screens are designed somewhat differently than the infrastructure measure screens. Charging for parking has three different levels to choose from based on cost to the employee. Select the appropriate parking charge or skip if free parking is provided. Measures for telecommuting and compressed work schedule require the user to enter the percent of the workforce participating in the program.

The next screen is for “Operational Measures (Applying to Employee Shopping Trips and Errands).” Select all measures that will apply to the project. A measure for providing onsite shops and services allows three levels of credit based on the number of services provided at the worksite. See the mitigation handbook for guidance on making this selection.

The next screen is for “Operational Measures (Applying to Customer/Client Trips).” Select from the customer parking charge that will apply to the site, if any, or add user measures as with the previous screens.

The final set of screens apply to “Measures Reducing Vehicle Miles Traveled (VMT)” for non-residential and residential projects. Provide the number of park and ride spaces or telecommuting workstations that will be provided by the developer. Any user measures added for these categories require you to enter the VMT estimated to be reduced.

After the last mitigation measure screen is completed, the program returns you to the “Set Travel Mode Environment” screen. Here you have the option of accepting the input you just made, returning you to the “Setting for Operational-Related Emissions,” or revising your environment and mitigation settings. The program also allows you to go backwards through the environment and mitigation screens to make changes by clicking on the previous screen button.

III.9 Outputting Results

To view the emissions output, you must click on the rightmost icon on the Icon Bar – the results icon - that appears as a yellow sheet of paper with lines on it. This will open up the output or results report.

The results output is similar to construction, area sources and operational screens in that the window is divided into a left and a right pane (see Figure 15). The left pane contains an expandable/collapsible list, with each item of the list designated as a node.

When first opened, the results screen presents the user with three nodes in the left pane:: lbs per day summer, lbs per day winter, and tons per year. By clicking on either of those three nodes, the user can expand the list to show summary and detailed report nodes. The Detail node can be expanded even further by clicking on either detail or the box to its left. Emission results for the current project can be seen in the right pane by clicking the cursor on the desired node in the left pane. The checkboxes associated with each node in the left pane are important because they identify the information sent to a printer or output file.

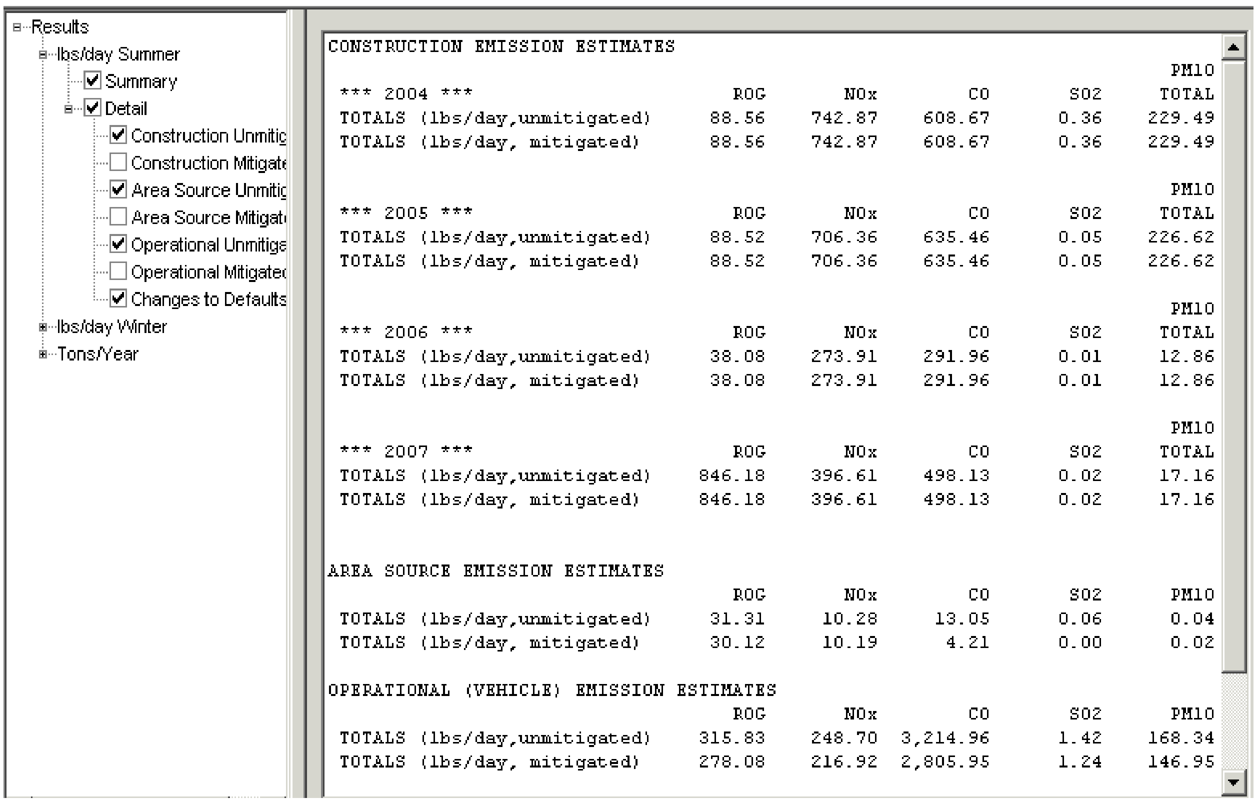

Figure 15. Output Emissions Screen

To send the output to the printer, the user can proceed in one of two ways. The easiest method is to click on the printer icon. Alternatively, the user can select “File” from the Menu, then “Print Selected Results”. If problems arise when printing, you may need to check the print destination by selecting “File” from the Menu, then “Select Print Destination” from the drop down menu.
The user also has the option of sending output to a file instead of a print, which is accomplished as follows. The user must first select “File” from the Menu, then the “Select Print Destination” from the drop down menu. A screen appears that allows the User to select a check box that sends the

output to a ascii file instead of to the printer. By selecting that check box, however, all future print jobs are sent to the output file until "Select Print Destination" is selected again by the user. One note of caution. Following this procedure tells URBEMIS2002 that the print destination is to a file rather than to the printer. You must still send the information to the printer by clicking on the printer icon or by selecting "File" from the Menu, then selecting "Print Selected Results". When you tell it to print (to a file), URBEMIS2002 will then ask for the name and location of the file to which you wish to send output.

The user must be aware of the color of the results icon when running URBEMIS2002. The results icon is found at the far right of the menu bar. The results icon is represented as a yellow pad with either black, red, or green lines. Initially, when the URBEMIS program is started but before any information has been added, the results icon is yellow with black lines. However, when information has been added or edited, the lines on the results icon turn green. This indicates that the icon must be clicked to get emission results that reflect the most recent changes. When the results icon lines are red, this indicates that the results reflect the most recent changes made to the current project. If the results icon is clicked when the lines are green, URBEMIS will recalculate the emission estimates. If the result icon is clicked when the lines are red, URBEMIS will simply show the results without recalculating emissions.

One key point to remember. You can view emission results by clicking on the results icon. Those results can be viewed as shown in Figure 15. However, those results may not represent the most recent changes made to a project unless the results icon has red lines. This can occur if you opt to view the emission results, leave the emission results screen open, then go back and change some project assumptions.

III.10 Setting Default Drives and Directories

Setting the correct default drives and directories is essential to running URBEMIS2002 successfully. Four sets of files are included with URBEMIS2002: land use project files, emission rate files, air district default files, and executable or "*.exe" files.

At startup, the program looks for a file called DIRECTRY.SAV on the default drive. The DIRECTRY.SAV file tells URBEMIS2002 the default drives and directories. If URBEMIS2002 finds the DIRECTRY.SAV file, then the program loads the main menu. If URBEMIS2002 cannot find the DIRECTRY.SAV file, then the program immediately sends you to the "Set Default Drives and Directories" screen.

Once there, you are prompted to select a default drive and directory for each of the three sets of files. To select a default drive or directory, you must position the cursor on the appropriate drive or directory and double click the left mouse button. Make sure that the three sets of directories are on the same drive; otherwise, the program will not run properly.

Once drives and directories have been selected, you must either press "OK" or "Cancel". Pressing "OK" saves the newly selected drives and directories to the DIRECTRY.SAV file. Pressing "Cancel" takes you back to the main menu without saving any changes to the DIRECTRY.SAV file. The "Cancel" button will not work if the DIRECTRY.SAV file does not exist on disk in the default executable directory, which is the program from which the program is started.

III.11 Saving to a File

Saving the project file to a disk file is essential if you want to rerun the program later. To save a file, either select the third icon (diskette icon) from the left on the Icon Bar, or click on "File" from the Menu and select "Save This Project" from the drop down menu. If a file with the same name already exists on disk, then URBEMIS2002 warns the user that a file with the same name already exists. The user can opt to save the file as a different name. URBEMIS2002 automatically gives files it creates a .urb extension.

III.12 Exiting the Program

URBEMIS2002 will not allow you to exit without closing all projects. Open projects, in turn, cannot be closed until all forms have been closed. Once all projects have been closed, URBEMIS2002 can be closed by either clicking on the X button in the top right hand corner of the screen or by selecting "File" from the Menu, then selecting "Close this Project" from the drop down menu.

References

California Air Resources Board. 1995a. Emission inventory 1993. Technical Support Division. Sacramento, CA.

California Air Resources Board. 1995b. URBEMIS computer program version 5.0 user guide vehicle-related emissions estimated for land development projects. Sacramento, CA.

Institute of Transportation Engineers. 1991. Trip generation. 5th edition, Washington, DC.

Institute of Transportation Engineers. 1995. Trip generation February 1995 update to the 5th edition. Washington, DC.

Institute of Transportation Engineers. 1997. Trip generation, 6th edition, Washington, DC.

Monterey Bay Unified Air Pollution Control District. 1995. CEQA air quality guidelines. Monterey, CA.

San Diego Association of Governments. 1996. San Diego traffic generators. California Department of Transportation, District 11. San Diego, CA.

Appendix A. Construction Emissions

Construction Emissions

URBEMIS2002 allows users to generate estimates of construction emissions (inhalable particulate matter [PM10], carbon monoxide [CO], reactive organic gases [ROG], sulfur oxides [SOx], and oxides of nitrogen [NOx]). Emissions can be estimated as pounds per day or tons per years. Emissions are estimated separately by phase and by phase component. Those phases and their associated components are as follows:

Phase 1 – Demolition Dust
Phase 1 – Demolition On-Road Diesel Exhaust
Phase 1 – Demolition Off-Road Diesel Exhaust
Phase 1 – Demolition Worker Commute Trips
Phase 2 – Site Grading Dust
Phase 2 – Site Grading On-Road Diesel Exhaust
Phase 2 – Site Grading Off-Road Diesel Exhaust
Phase 2 – Site Grading Worker Commute Trips
Phase 3 – Subphase 1: Building Construction Off-Road Diesel Exhaust
Phase 3 – Subphase 1: Building Construction Worker Commute Trips
Phase 3 – Subphase 2: Architectural Painting Off-Gas Emissions
Phase 3 – Subphase 2: Architectural Painting Worker Commute Trips
Phase 3 – Subphase 3: Asphalt Paving Off-Gas Emissions
Phase 3 – Subphase 3: Asphalt Paving Off-Road Diesel Exhaust
Phase 3 – Subphase 3: Asphalt Paving On-Road Diesel Exhaust
Phase 3 – Subphase 3: Worker Trips

The methodology used to estimate emissions associated with each of the phase components is described below. The user should be aware that off-road diesel exhaust SOx emissions are not currently calculated by URBEMIS2002.

Phase 1 – Demolition Emissions

Demolition Dust

If the user chooses to estimate construction emissions, the user will be prompted to select the types of construction emissions that they would like to estimate. If the user selects demolition emissions, then the user is prompted to enter the total volume of all buildings to be demolished and the maximum volume of all buildings to be demolished in a single day. URBEMIS2002 calculates the total days required to complete demolition activities.

The following equation is used to estimate daily PM10 generated by demolition:

$$\text{PM10 (pounds/day)} = (0.00042 \text{ pounds of PM10 / feet}^3) * (N * O * P) / Q.$$

Where: N = building width (feet)
O = building length (feet)
P = building height (feet)
Q = number of days required to demolish the building(s).

This equation is based on Table A9-9-H of the South Coast Air Quality Management District's (SCAQMD's) California Environmental Quality Act (CEQA) Air Quality Handbook (South Coast Air Quality Management District 1993).

URBEMIS2002 does not provide default information on building dimensions slated for demolition. The user must provide URBEMIS2002 with that information to estimate demolition emissions. The user has the option of entering building width, length, and height or entering total building volume.

Demolition On-Road Diesel Exhaust

The demolition emission estimates also include exhaust emissions from the construction equipment involved in the demolition, including the on-road vehicles used to haul demolished materials to the nearest landfill. Based on information provided by the user regarding the building volume to be demolished, URBEMIS generates default information regarding demolition hauling. That information, shown in Table A-1, can be overridden by the user. For example, URBEMIS assumes a hauling round trip of 20 miles and a truck capacity of 20 cubic yards unless overridden by the user. Similarly, URBEMIS generates a default estimate of the number of round trips required per day using the following equation:

Round trips/day = Total yd^3 to be demolished/days demolition * trip/20 yd^3

The total cubic yards to be demolished will be entered into URBEMIS by the user, and the number of days required for demolition will be calculated using the Phase 1 length entered by the user. The vehicle miles traveled per day for demolition is estimated by multiplying the miles per round trip by the round trips per day. That value is then multiplied by the appropriate EMFAC2002 emission factor for heavy-duty on-road vehicles using the following equation:

Haul Emissions (pounds/day) = vehicle miles traveled/day * grams pollutant/mile (from EMFAC2002) * pound/454 grams

Table A-1. Demolition Truck Hauling Assumptions

Demolition Hauling	User Override
Truck capacity (cubic yards)	20
Miles/round trip	20
Round trips/day	10 (Calculated from user input)
Vehicle miles traveled/day (calculated)	200

Demolition – Off Road Diesel Exhaust

In addition to truck hauling, demolition emissions are generated by the operation of other construction equipment, such as concrete saws, cranes, and bulldozers. The URBEMIS user is presented with a list of construction equipment, as shown in Table A-2. Because of the widely varying nature of demolition, default values for these types of equipment are not generated by URBEMIS. Instead, the user is required to select the number of each type of equipment that will be used. The user will have the option of overriding the default values for horsepower, hours per day, and load factor.

Table A-2. Construction Equipment Used for Demolition

Equipment	Pieces of Equipment	Default Values		
		Horsepower	Load Factor	Hours/Day
Bore/drill rigs		218	0.75	8.0
Concrete/ industrial saws		84	0.73	8.0
Cranes		190	0.43	8.0
Crawler tractors		143	0.575	8.0
Crushing/ processing equipment		154	0.78	8.0
Excavators		180	0.58	8.0
Graders		174	0.575	8.0
Off-highway tractors		255	0.41	8.0
Off-highway trucks		417	0.49	8.0
Other construction equipment		190	0.62	8.0
Pavers		132	0.59	8.0
Paving equipment		111	0.53	8.0
Rollers		114	0.43	8.0
Rough-terrain forklifts		94	0.475	8.0
Rubber-tired dozers		352	0.59	8.0
Rubber-tired loaders		165	0.465	8.0
Scrapers		313	0.66	8.0
Signal boards		119	0.82	8.0
Skid steer loaders		62	0.515	8.0
Surfacing equipment		437	0.49	8.0
Tractors/loaders/ backhoes		79	0.465	8.0
Trenchers		82	0.695	8.0

Source: Default values for horsepower, load factor, and hours per day of operation from the California Air Resources Board's off-road model. These default values can be overridden by the user.

For each piece of equipment selected, URBEMIS generates an emission estimate. The emission equation used by URBEMIS for each piece of equipment is as follows:

Equipment Emissions (pounds/day) = # of pieces of equipment * grams per brake horsepower-hour * equipment horsepower * hours/day * load factor

Where: grams per brake-horsepower hour is based on the construction year and on the average life expectancy of the equipment type. Grams per brake horsepower per hour emissions and average equipment life expectancy are from Appendix B of the California Air Resources Board's (ARB's) off–road model (California Air Resources Board 2000). The pounds per day emission factors are found in Appendix H of this manual.

Demolition Worker Commute Trips

Worker trips are estimated separately by each of the three construction phases. For demolition, the number of workers will be estimated as 125% of the total number of construction equipment (vehicles and machines) selected. The emission estimates assume a construction worker commute fleet mix of 50% light duty autos and 50% light duty trucks. The worker commute travel distance, speed, and temperature are based on the worker.

Phase 2: Site Grading Emissions

Phase 2 - Site Grading Fugitive Dust

The fugitive dust emission estimates within URBEMIS2002 use the methodology developed for SCAQMD by the Midwest Research Institute. That four-tiered methodology allows for more refined PM10 estimates based on the level of detail known for the construction project. Previous versions of URBEMIS only provided emissions for the Level 1 or default level. URBEMIS now estimates emissions using the level of detail known for a project, as shown in Table A-3.

Table A-3. Fugitive Dust Estimation Approach

Basis for Emission Factor	Recommended PM10 Construction Emission Factor
Default Level: Only area and duration known	Apply 0.11 tons/acre-month (average conditions) Apply 0.42 ton/acre-month (worst-case conditions)
Low Level of Detail: Area and amount of earthmoving known	Apply 0.11 ton/acre-month for each month of construction activity Plus 0.059 ton/1,000 yd^3 of onsite cut/fill Plus 0.22 ton/1,000 yd^3 of offsite cut/fill These values assume that one scrapper can move 70,000 yd^3 of earth in one month and 35,000 yd^3 of material can be moved by truck in one month. If the on-/offsite fraction is not known, assume 100% onsite.
Medium Level of Detail: More detailed information available on duration of earthmoving and other material movement	Apply 0.13 lb/acre-work hr Plus 49 lb/scraper-hr for onsite haulage Plus 94 lb/hr for offsite haulage
High Level of Detail: Detailed information known on acres, hours or construction work, number of truck units or VMT, and truck travel distances.	Apply 0.13 lb/acre-work hr Plus 0.21 lb/ton-mile for onsite haulage Plus 0.62 lb/ton-mile for offsite haulage

A key component of the site grading dust emissions is the maximum acreage that will be disturbed on a daily basis. URBEMIS2002 estimates a default acreage graded per day based on the land use sizes specified by the user. For single-family residential units, URBEMIS2002 assumes five units per acre. For multifamily units, URBEMIS2002 assumes 20 units per acre. For commercial uses, URBEMIS2002 assumes that the total project acreage equals twice the size of each building's square footage. For example, URBEMIS2002 assumes that a 100,000-square-foot industrial park would require 200,000 square feet (4.6 acres) of land disturbance. As a default estimate, the revised version of URBEMIS2002 will assume that 25% of total land acreage slated to be disturbed will actually be disturbed on the worst-case day, up to a maximum of 10 acres. If the total acreage to be disturbed on the worse-case day exceeds 10 acres, then URBEMIS caps the total at 10 acres unless overridden by the user. URBEMIS will provide the user with a form similar to that shown in Table A-4. The user will have the option of modifying URBEMIS' estimates of the maximum acreage to be disturbed per day.

In the example shown in Table A-4, a project that includes 100 units of single-family residential, 100 units of multi-family residential, and 100,000 square feet of commercial development will result in a total estimated acreage of 29.6 acres. Assuming that 25% of that total acreage is graded on the worse-case day, the maximum acreage disturbed equals 7.5 acres. However, the user has overridden that value, indicating that a maximum of 5 acres will be disturbed.

Table A-4. Acreage Estimates for Grading

Land Use	User-Entered Values	Estimated Acreage	Estimated Maximum Acreage Disturbed per Day
Residential—Single Family	100 units	20	5
Residential—Multi-family	100 units	5	1.3
Commercial	100,000 sq. ft.	4.6	1.2
Totals	Not applicable	29.6	5

Phase 2 - Site Grading Equipment Off-Road Diesel Exhaust

Site grading emissions are generated by the operation of off-road construction equipment, such as scrapers, bulldozers, and loaders. The URBEMIS user is presented with a list of construction equipment, as shown previously in Table A-2. The user has the option of either select the number of each type of equipment that will be used or having URBEMIS generate estimates of construction use.

To estimate off-road construction equipment-related construction exhaust emissions, URBEMIS uses an approach based on ARB's off-road emissions model (California Air Resources Board 2000). That model uses a methodology in which emission factors for construction equipment are based on an average fleet mix that accounts for the turnover rate and average emissions for specific types of construction equipment. URBEMIS generates default values and allows the user to override the defaults for equipment horsepower and load factors.

For each piece of equipment selected, URBEMIS generates an emission estimate. The emission equation that will be used by URBEMIS for each piece of equipment is as follows:

Equipment Emissions (pounds/day) = # of pieces of equipment * grams per brake horsepower-hour * equipment horsepower * hours/day * load factor

Where: grams per brake-horsepower hour is based on the construction year and on the average life expectancy of the equipment type. Grams per brake horsepower per hour emissions and average equipment life expectancy are from the California Air Resources Board's (ARB's) off–road model (California Air Resources Board 2000). (See Appendix I of this manual for off-road vehicle emission rates.)

Phase 2 - Site Grading On-Road Diesel Exhaust

One additional enhancement to URBEMIS' treatment of grading equipment exhaust involves specifying whether the project will require soil to be imported to or exported from the site. If soil is to be imported or exported, the user must to enter the volume of soil. URBEMIS will use that information to calculate the number of on-road vehicle trucks trips and vehicle miles traveled per day (as shown in Table A-5). The user will have the option of overriding the default assumptions programmed into URBEMIS.

Table A-5. Construction Grading Soil-Hauling Assumptions

Soil Import/Export Hauling	Parameter
Amount of soil to import (cubic yards)	0
Amount of soil to export (cubic yards)	0
Total soil imported + exported (cubic yards)	0
Haul-truck capacity (cubic yards)	15
Number of days to conduct hauling	20
Round trips/day	3.3
Round-trip distance (miles)	20
Vehicle miles traveled/day (calculated)	66

Once vehicle miles traveled per day is known, URBEMIS calculates haul-trip emissions using the following formula:

On-Road Haul Truck Emissions (pounds/day) = vehicle miles traveled/day * grams pollutant/mile (from EMFAC2002) * pound/454 grams

Site Grading Worker Commute Trips

Worker trips are estimated separately by each of the three construction phases. For site grading, the number of workers is estimated as 125% of the total number of construction equipment (vehicles and machines) selected. The emission estimates assume a construction worker commute fleet mix of 50% light duty autos and 50% light duty trucks. The worker commute travel distance, speed, and temperature are based on the trip characteristics information for home to work trips found under the trip characteristics node of the operational emissions module.

Phase 3: Building Construction

Phase 3 – Subphase 1: Building Construction Off-Road Diesel Exhaust

Building construction emissions consist of emissions produced during building construction. Building construction equipment includes sources such as compressors, generators, gas-powered saws, and forklifts.

Table A-6 lists equipment typically used during building construction. The number and type of equipment can vary substantially, depending on the type of building and its location. The amount of concrete, masonry, wood, and metal products used in building construction varies widely, and can have a large impact on the type of construction equipment needed for a construction project.

The default values shown in Table A-6 are worst-case estimates for each 2,000 square feet of building construction (Frank R. Walker Company 1999). These estimates assume the use of one forklift to unload materials from supply trucks and move them around the site, one concrete/industrial saw (or similar type of equipment), and two other types of construction equipment, such as supply trucks bringing materials like concrete, wood, steel, or other building products to the site. The user should always use project specific information, when available. If unavailable, however, the user can let URBEMIS calculate the equipment type and number by hitting the Recalc with Land Uses Button.

Table A-6. Construction Equipment Used for Building Construction

Equipment	URBEMIS Estimate—Pieces of Equipment	User Override—Pieces of Equipment	Default Values		
			Horsepower	Load Factor	Hours/Day
Bore/drill rigs			218	0.75	8.0
Concrete/ industrial saws	1		84	0.73	8.0
Cranes			190	0.43	8.0
Crawler tractors			143	0.575	8.0
Crushing/ processing equipment			154	0.78	8.0
Excavators			180	0.58	8.0
Graders			174	0.575	8.0
Off-highway tractors			255	0.41	8.0
Off-highway trucks			417	0.49	8.0
Other construction equipment	2		190	0.62	8.0
Rollers			114	0.43	8.0
Rough-terrain forklifts	1		94	0.475	8.0
Rubber-tired dozers			352	0.59	8.0

Equipment	URBEMIS Estimate—Pieces of Equipment	User Override—Pieces of Equipment	Default Values		
			Horsepower	Load Factor	Hours/Day
Rubber-tired loaders			165	0.465	8.0
Scrapers			313	0.66	8.0
Signal boards			119	0.82	8.0
Skid steer loaders			62	0.515	8.0
Surfacing equipment			437	0.49	8.0
Tractors/loaders/ backhoes			79	0.465	8.0
Trenchers			82	0.695	8.0

Sources: Default values for horsepower, load factor, and hours per day of operation from the California Air Resources Board's off-road model (200). Pieces of equipment are based on 2,000 square feet of building construction and on information in Walker's Building Estimator's Reference Book (Frank R. Walker Company 1999).

Phase 3 – Subphase 1: Building Construction Worker Commute Trips

Emissions from construction worker vehicle commute trips are estimated by multiplying total daily employee vehicle miles traveled (VMT) by an emission rate (grams per mile). URBEMIS2002 estimates construction-related employee trip generation as follows. Each land use type selected as part of the project is grouped into one of four general land use categories: multifamily, single-family, commercial/retail, and office/industrial. Then, for each category, the number of trips is estimated using the following equations:

Multifamily Trips = 0.36 trips/unit * number of units
Single-Family Trips = 0.72 trips/unit * number of units
Commercial or Retail Trips = 0.32 trips/1,000 feet^2 * number of 1,000 feet^2
Office or Industrial Trips = 0.42 trips/1,000 feet^2 * number of 1,000 feet^2

These trip generation rates are based on information contained in the Sacramento Metropolitan Air Quality Management District's Air Quality Thresholds of Significance Handbook (Sacramento Metropolitan Air Quality Management District (1994).

URBEMIS2002 then totals trips from the four general land use categories and multiplies by the average trip length to obtain daily VMT. Trip length is found under the trip characteristics node of the operational emissions module of URBEMIS. URBEMIS2002 uses the construction year identified by the user to select EMFAC emission rates that will be multiplied by VMT/day.

Phase 3 – Subphase 2: Architectural Painting Off-Gas Emissions

URBEMIS2002 estimates ROG emissions resulting from the evaporation of solvents contained in paints, varnishes, primers, and other surface coatings. Separate procedures are used to estimate evaporative emissions from application of residential and nonresidential architectural coatings. The following emission factors are used for residential coating emissions:

ROG (pounds / day) = ((0.0185 pounds of ROG per $foot^2$ surface area) * ((Number of single-family units * square feet per unit) + (Number of multi-family units * square feet per unit)) * 2.7)) * mil thickness) / (number of days to paint)

The following equation is used for estimating nonresidential architectural coatings emissions:

ROG (pounds/day) = (((0.0185 pounds ROG / $foot^2$ surface area) * (Sum of Individual Building Square Footage * 2.0)) * mil thickness) / (Number of Days to Paint)

For the residential equation, the factor 2.7 is used to convert building area to surface area. For nonresidential coatings, the value of 2.0 is used to convert building area to surface area. URBEMIS2002 uses the length of the painting subphase as the time required to complete the painting. URBEMIS2002 also assumes that single-family homes average 1,800 $feet^2$ and multifamily homes average 850 $feet^2$. The number of units to be painted is based on land use information provided by the user.

The URBEMIS2002 calculation assumes a ROG emission rate of 0.0185 pounds of ROG per square foot, which represents a waterborne coating assumed to have 47.67 percent by weight solids, 10.54 pounds per gallon density, 250 grams per liter VOC content, and a coating thickness of one mil (0.001 inch).

The user has the option of altering the ROG emission rate, paint thickness, conversion ratio (building area to surface area), and the number of days required to complete the painting.

Phase 3 – Subphase 2: Architectural Painting Worker Commute Trips

The worker commute trip emissions associated with architectural painting is assumed to equal those for Subphase 1.

Phase 3 – Subphase 3: Asphalt Paving Off-Gas Emissions

URBEMIS2002 estimates ROG emissions associated with asphalt paving. The emissions are estimated based on the procedure identified in the SMAQMD manual (Sacramento Metropolitan Air Quality Management District 1994). ROG emissions are estimated using the following formula:

ROG (pounds per day) = (2.62 pounds ROG / acre) * (total acres paved / paving days)

Phase 3 – Subphase 3: Asphalt Paving Off-Road Diesel Exhaust

URBEMIS2002 now includes emissions from the heavy-duty equipment involved in laying asphalt. The typical procedure used in asphalt paving includes final grading (grader), rolling (roller), applying a base course of rock or aggregate (two on-road trucks, one off-road water truck), additional rolling (roller), spraying a tack coat (paving equipment), paving (paver), and final rolling (roller) (Asphalt Institute 2002).

Table 11 shows the equipment that URBEMIS assumes will be used in paving each 0.5 acre per day. URBEMIS takes the total acreage to be paved (as entered in the asphalt off-gas emissions screen)

and divides by the length in days of asphalt paving. Unless overridden, URBEMIS assumes the number of pieces of equipment in Table A-7 for each 0.5 acre paved per day.
The equation that will be used to estimate equipment emissions is as follows:

> Off-Road Equipment Emissions (pounds/day) = # of pieces of equipment * grams per brake horsepower-hour * equipment horsepower * hours/day * load factor

Table A-7 Construction Equipment Used for Paving/Asphalt Installation

Equipment	URBEMIS Estimate—Pieces of Equipment	User Override—Pieces of Equipment	Default Values		
			Horsepower	Load Factor	Hours/Day
Bore/drill rigs			218	0.75	8.0
Concrete/ industrial saws			84	0.73	8.0
Cranes			190	0.43	8.0
Crawler tractors			143	0.575	8.0
Crushing/ processing equipment			154	0.78	8.0
Excavators			180	0.58	8.0
Graders	1		174	0.575	8.0
Off-highway tractors			255	0.41	8.0
Off-highway trucks	1		417	0.49	8.0
Other construction equipment			190	0.62	8.0
Pavers	1		132	0.59	8.0
Paving equipment	1		111	0.53	8.0
Rollers	2		114	0.43	8.0
Rough-terrain forklifts			94	0.475	8.0
Rubber-tired dozers			352	0.59	8.0
Rubber-tired loaders			165	0.465	8.0
Scrapers			313	0.66	8.0
Signal boards			119	0.82	8.0
Skid steer loaders			62	0.515	8.0
Surfacing equipment			437	0.49	8.0
Tractors/loaders/ backhoes			79	0.465	8.0
Trenchers			82	0.695	8.0

Phase 3 – Subphase 3: Asphalt Paving On-Road Diesel Exhaust

URBEMIS estimates vehicle miles traveled per day for asphalt hauling using information entered by the user regarding acreage to be paved per day. Using that information, URBEMIS estimates the total volume per day of asphalt required by multiplying acreage by an assumed asphalt thickness of 3 inches (Frank R. Walker Company 1999). The asphalt volume is then used to estimate the number of truck trips, assuming a truck volume capacity of 20 cubic yards. Vehicle miles are estimated based on the number of truck trips, and haul emissions are estimated using the following equation:

On-Road Asphalt Haul Truck Emissions (pounds/day) = vehicle miles traveled/day * grams pollutant/mile * pound/454 grams

Phase 3 – Subphase 3: Asphalt Worker Trips

Asphalt worker trips are estimated separately by each of the three construction phases. For asphalt paving, the number of workers is estimated as 125% of the total number of construction equipment (vehicles and machines) selected. The emission estimates assume a construction worker commute fleet mix of 50% light duty autos and 50% light duty trucks. The worker commute travel distance, speed, and temperature are based on the trip characteristics information for home to work trips found under the trip characteristics node of the operational emissions module.

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Appendix A References

Asphalt Institute. 2002. Asphalt Institute – asphalt pavement construction FAQs. Last revised May 31. Available: http://www.asphaltinstitute.org/faq/apcfaqs.htm.

California Air Resources Board. 2000. Public meeting to consider approval of California's emissions inventory of off-road large compression-ignited engines (25 hp) using the OFFROAD emissions model (Staff Report). Sacramento, CA.

Frank R. Walker Company. 1999. Walker's building estimator's reference book, 26th edition. Lisle, Il.

ITE (Institute of Transportation Engineers). 1997. Trip generation, 6th edition. Washington, DC.

Midwest Research Institute (MRI). 1996. Improvement of Specific Emission Factors (BACM Project No. 1) Final Report. Prepared for the South Coast AQMD. November 14, 1995. Kansas City, MO.

Sacramento Metropolitan Air Quality Management District. 1994. Air quality thresholds of significance, first edition. Sacramento, CA.

Sandag (San Diego Association of Governments). 1996. San Diego traffic generators. San Diego, CA.

South Coast Air Quality Management District. 1993. CEQA air quality handbook. Diamond Bar, CA.

U.S. Environmental Protection Agency. 1985. Compilation of air pollutant emission factors, volume I: stationary, point, and area sources, and volume II: mobile sources, fourth edition. Research Triangle Park, North Carolina.

Appendix B. Area Source Emissions

Area Source Emissions

URBEMIS2002 has been enhanced so that both novice and experienced users can generate accurate estimates of area source emissions. Novice users can generate estimates using default assumptions programmed into URBEMIS2002. Users experienced in estimating area source emissions can modify the area source assumptions to suit their particular project.

URBEMIS2002 allows the user to estimate area source emissions from:

- fuel combustion emissions from space and water heating, including wood stoves and fireplaces;
- fuel combustion emissions from landscape maintenance equipment; and
- consumer product ROG emissions.

FUEL COMBUSTION EMISSIONS FROM WATER AND SPACE HEATING

Natural Gas Combustion

URBEMIS2002 can be used to estimate fuel combustion emissions from water and space heating using the approach described in Tables A9-12, A9-12-A, and A9-12-B in the South Coast Air Quality Management District CEQA handbook (South Coast Air Quality Management District 1993) and emission factors developed by the U.S. Environmental Protection Agency (U.S. EPA 1995). With one exception, all emission estimates assume natural gas is used as the primary source of water and space heating. The one exception is wood used for fireplaces and wood stoves. The equation used to estimate CO, ROG, NOx, and PM10 emissions from natural gas combustion is as follows for each land use type:

Emissions = H * ({[F*G]/30}/1,000,000) * P

Where: H = emission factor for each criteria pollutant in pounds of pollutant per million cubic feet of natural gas consumed (CO: 40 pounds/MMfoot^3; ROG: 7.26 pounds/MMfoot^3; NOx: 94.0 pounds/MMfoot^3 [residential], NOx 100.0 pounds/MMfoot^3 [nonresidential]; PM10: 0.18 pounds/MMfoot^3)

F = units per land use type: residential (number of units)
industrial (customers)
hotel/retail/office (square feet)

G = Natural gas usage rates:

Residential: Single-Family: 6,665.0 feet^3 / unit / month
Multifamily: 4,011.5 feet^3 / unit / month

Nonresidential: industrial: 241,611 feet^3 / customer / month
hotel/motel: 4.8 feet^3 / square feet / month

retail/shopping: 2.9 $feet^3$ / square feet / month
office: 2.0 $feet^3$ / square feet / month

P = percentage using natural gas

Residential 100%
Nonresidential 100%

Wood Combustion –Wood Stoves

Wood stove emissions can be estimated using the following equation:

Wood Stove Emissions (pounds per day) = ((A * C) + (B * D) + (E * F) + (J * K)) * (G) * (H * I)

Where:

A = EPA-certified noncatalytic stove emission rate (grams pollutant per ton of kilogram wood burned)
B = EPA-certified catalytic stove emission rate (grams pollutant per kilogram of wood burned)
C = Percent of all stoves assumed to be noncatalytic
D = Percent of all stoves assumed to be catalytic
E = Conventional wood stove emission rate (grams pollutant per kilogram wood)
F = Percent of all stoves assumed to be conventional
G = Cords of wood burned per year per residential unit
H = Number of residential units
I = Percentage of residential units with wood stoves
J = Pellet stove emission rate (grams pollutant per kilogram wood burned)
K = Percent of all stoves assumed to be pellet

URBEMIS2002 assumes the following defaults for wood stove emissions:

A = 9.8 grams PM10 / kilogram, 70.4 grams CO / kilogram, 7.5 grams ROG / kilogram, 1.4 grams NOx / kilogram
B = 10.2 grams PM10 / kilogram, 52.2 grams CO / kilogram, 7.8 grams ROG / kilogram, 1.0 grams NOx / kilogram
C = 50% (entered as 0.50)
D = 50% (entered as 0.50)
E = 15.3 grams PM10 / kilogram, 115.4 grams CO / kilogram, 21.9 grams ROG / kilogram, 1.4 grams NOx / kilogram
F = 0.0%
G = 1.48 cords per year per residential unit
H = based on land uses specified by the user
I = 35% (entered as 0.35)
J = 2.1 grams PM10 / kilogram, 19.7 grams CO / kilogram, 0.01 grams ROG / kilogram, 6.9 grams NOx / kilogram
K = 0.0%

The emission factors shown above are based on EPA's AP-42 document (U.S. Environmental Protection Agency 1995). The emission factor assumes an even split between noncatalytic, catalytic, and pellet stoves. The default assumption assumes that no conventional nor stoves will be included, although the equation will allow the user to include conventional stoves in the emission calculation. Annual emissions assume 2.71 tons wood (1.48 cords) would be burned per stove per residential unit during the heating season.

Wood Combustion –Fireplaces

Fireplace emissions are estimated using the following equation:

Fireplace Emissions (pounds per day) = (J * K * L * M)

Where:

J = Fireplace emission rate (pounds of pollutant per residential unit per ton of wood burned)
K = Cords of wood burned per day year residential unit
L = Number of residential units
M = Percentage of residential units with wood stoves

URBEMIS2002 will assume the following defaults for fireplace emissions:

J = 34.6 pounds of PM10 / ton, 252.6 pounds of CO / ton, 229.0 pounds of ROG / ton, 2.6 pounds of NOx / ton
K = 1.48 cords burned per year per residential unit
L = residential units are based on the residential land uses specified by the user
M = 10% (entered as 0.10)

These emission rates are based on information published by EPA (U.S. Environmental Protection Agency 1995). As with wood stove emissions, the user can modify each of the variables used to estimate fireplace emissions. Annual emissions are estimated based on annual wood combustion.

FUEL COMBUSTION EMISSIONS FROM LANDSCAPE MAINTENANCE

Landscape maintenance equipment generates emissions from fuel combustion and from evaporation of unburned fuel. Emissions include NOx, ROG, CO, and PM10. Equipment in this category includes lawn mowers, roto tillers, shredders/grinders, blowers, trimmers, chain saws, and hedge trimmers used in residential and commercial applications. This category also includes air compressors, generators, and pumps used primarily in commercial applications (California Air Resources Board 1992a).

The California Air Resources Board has enacted regulations to limit emissions from landscape maintenance equipment (California Air Resources Board 1992b). Beginning in 1994 these regulations impose emission limits on all landscape maintenance equipment sold. Those regulations become more stringent for equipment sold in 1999 and later. Consequently, the emissions from this source category are similar to automobile emissions in that the turnover in the equipment fleet plays an important part in how quickly emission reductions are achieved.

URBEMIS2002 estimates emissions from this source category based on the year in which the user is attempting to estimate emissions. The California Air Resources Board has prepared estimates of emissions in 1989 and emission reductions expected by 2010. The proposed equations for this source category are divided into residential and commercial categories. The residential equation applies only to SFHU. The commercial equation is based on emissions per business unit and includes multifamily residential land uses.

<u>1989 Emissions - Residential</u>
ROG (pounds/day) = 0.003 pounds ROG / SFHU/day * SFHU
CO (pounds/day) = 0.024 pounds CO / SFHU/day * SFHU
NOx (pounds/day) = 0.0002 pounds NOx / SFHU/day * SFHU
PM10 (pounds/day) = 0.00006 pounds PM10 / SFHU/day * SFHU
SO_2 (pounds/day) = 0.0007 pounds SO_2 / SFHU/day * SFHU

<u>1989 Emissions - Commercial</u>
ROG (pounds/day) = 0.175 pounds ROG / Business Unit * Number Business Units
CO (pounds/day) = 1.149 pounds CO / Business Unit * Number Business Units
NOx (pounds/day) = 0.007 pounds NOx / Business Unit * Number Business Units
PM10 (pounds/day) = 0.0041 pounds PM10 / Business Unit * Number Business Units
SO_2 (pounds/day) = 0.0001 pounds SO_2 / Business Unit * Number of Business Units

<u>2010 Emissions - Residential</u>
ROG (pounds/day) = 0.00054 pounds ROG / SFHU/day * SFHU
CO (pounds/day) = 0.00576 pounds CO / SFHU/day * SFHU
NOx (pounds/day) = 0.00014 pounds NOx / SFHU/day * SFHU
PM10 (pounds/day)= 0.000005 pounds PM10 / SFHU/day * SFHU
SO_2 (pounds/day) = 0.0002 pounds SO_2 / SFHU/day * SFHU

<u>2010 Emissions - Commercial</u>
ROG (pounds/day) = 0.0315 pounds ROG / Business Unit *Number Business Units
CO (pounds/day) = 0.276 pounds CO / Business Unit * Number Business Units
NOx (pounds/day) = 0.005 pounds NOx / Business Unit * Number Business Units
PM10 (pounds/day)= 0.00037 pounds PM10 / Business Unit * Number Business Units
SO_2 (pounds/day) = 0.0001 pounds SO_2 / Business Unit * Number Business Units

The residential emission factors shown in the 1989 emission equations are based on total residential emissions from this source category in the San Joaquin Valley divided by the San Joaquin Valley's total 1989 SFHUs. Similarly, the commercial emission factors for 1989 are based on total San Joaquin Valley commercial emissions divided by the Valley's total 1989 business units (U.S. Department of Commerce 1991). For the commercial equations, URBEMIS2002 bases the number of business units on the number of individual land use categories specified by the user (excluding single family residential).

The 2010 emission rates are based on ARB's estimates that, by 2010, the regulation will reduce ROG emissions by 82%, CO by 76%, PM10 by 91%, NOx by 28%, and SO_2 by 50%.

The regulations for this source category took effect in 1994 and became more stringent in 1999. URBEMIS2002 uses the emission rates shown for 1989 for 1990 through 1993. For 1994 through 2009, URBEMIS2002 interpolates emission factors by assuming a uniform decrease in the emission rate each year. In 2010 and succeeding years, the 2010 emission rates will be used.

Average annual emissions assume that daily emissions would occur only during the summer period of 180 days. The end user will be able to modify the length of the summer period.

CONSUMER PRODUCT EMISSIONS

Consumer product emissions are generated by a wide range of product categories, including air fresheners, automotive products, household cleaners, and personal care products. Emissions associated with these products primarily depend on the increased population associated with residential development (California Air Resources Board 1990). Consequently, URBEMIS2002 can be used to estimate consumer product emissions when one or more residential land uses have been selected by the user. Emissions would be based on the following equation:

ROG (pounds/day) = 0.0171 pounds of ROG per person * Number of residential units * 2.861 persons per unit

The ROG emission factor is based on the total estimated ROG emissions from consumer products divided by the total California population (California Air Resources Board 1990; California Department of Finance 1994). Persons per household is based on the 1990 census information for California (California Department of Finance 1994).

URBEMIS2002 will base the number of residential units on information provided by the user on residential land uses. The user can modify each of the variables in the ROG emissions equation.

Annual emissions are estimated by multiplying pounds of ROG emitted per day by 365 days per year.

Appendix B References

California Air Resources Board. 1990. Proposed regulation to reduce volatile organic compound emissions from consumer products, staff report. Sacramento, CA.

California Air Resources Board. 1992a. Attachment C. technical support document for California exhaust emission standards and test procedures for 1994 and subsequent model year utility and lawn and garden equipment engines.

California Air Resources Board. 1992b. Attachment A. Sections 28 and 29 of the California exhaust emission standards and test procedures for 1994 and later utility and lawn and garden equipment engines.

California Department of Finance. 1994. California statistical abstract. Sacramento, CA.

South Coast Air Quality Management District. 1993. CEQA air quality handbook. Diamond Bar, CA.

U.S. Department of Commerce. 1991. County business patterns 1989 California. Bureau of the Census, Washington, DC.

U.S. Environmental Protection Agency. 1995. AIR CHIEF CD-ROM Version 4.0. Research Triangle Park, North Carolina.

Appendix C. Operational (Motor Vehicle) Emissions

Exhaust Emission Factors

URBEMIS2002 estimates vehicle exhaust emissions using several pieces of input entered by the user. That information is found within the URBEMIS input screens of the operational emissions module. The operational emissions module input screens include project year, vehicle fleet percentages, winter and summer temperature, trip characteristics, variable start information, and the percentage of travel on paved versus unpaved roads.

Once the user has entered the appropriate information into the operational emissions input screens and selects the emissions output, URBEMIS2002 calls the appropriate summertime and wintertime EMFAC2002 files based on the analysis year selected by the user. URBEMIS then goes to the appropriate locations within those files based on the average vehicle speeds and temperature. For each pollutant, URBEMIS obtains information from several locations within the EMFAC input file. For certain pollutants, URBEMIS generates pounds per mile emission estimates by multiplying the grams per mile values for each technology class within EMFAC (fleet mix vehicle type and technology class [non-catalyst, catalyst, diesel] by the percentage supplied by the user in the fleet mix screen. This results in a fleet average grams per mile value, which is then converted to pounds per day.

A similar approach is used to estimate trip emissions for certain pollutants. Separate tables in EMFAC2002 contain grams per trip emissions based on the length of time since the vehicle engine was turned off. URBEMIS uses the variable starts table, which shows the percentage of vehicles in several time classes (minutes since the vehicle engine was turned off) and for the six trip modes. URBEMIS uses the information in the variable starts table and the grams per trip values within EMFAC2002 to estimate weighted grams per trip values. The weighted grams per trip value is then multiplied by the number of trips calculated from the land use information to estimate total emissions per trip per pollutant.

Once the EMFAC2002 file has been read, URBEMIS2002 calculates criteria pollutant emissions for:

- running exhaust (grams per mile of ROG, CO, NOx, PM10),
- tire wear particulates (grams per mile, PM10),
- brake wear particulates (grams per mile, PM10),
- variable starts (grams per trip, ROG, CO, NOx),
- hot soaks (grams per trip, ROG),
- diurnals (grams per hour, ROG) ,
- resting losses (grams per hour, ROG), and
- evaporative running losses (grams per mile, ROG).

The estimated operational criteria pollutant emissions are summed in the emissions output page.

Entrained Road Dust Emissions

Entrained road dust emissions are generated by vehicles traveling on both paved and unpaved roads. URBEMIS2002 provides end users with a default percentage of VMT for paved versus unpaved roads. End users are asked whether they want to modify those percentages. Default percentages assume that 100 percent of VMT occurs on paved roads and 0 percent on unpaved roads.

Paved Roads.

For paved roads, URBEMIS2002 uses the following equation:

$$PAVED = k\,(sL/2)^{0.65}\,(W/3)^{1.5}$$

Where:

PAVED = particulate emission factor (lb/VMT);
k = particle size multiplier for particle size range and units of interest;
sL = road surface silt loading (grams per square meter);
W = average weight of the vehicles traveling the road (megagrams).

The following default assumptions are used by URBEMIS2002:

k = 0.016 (for the 10 microns and under particle size cutoff)
sL = 0.1 (allowable range of 0.02 – 400 grams per square meter)
W = 2.2 (allowable range of 1.8-38 megagrams)

This equation is based on the paved roads emission factor found in AP-42 (U.S. Environmental Protection Agency 2003a). URBEMIS2002 allows the user to modify silt loading (sL) and average vehicle fleet weight (W). The equation was developed using silt loads ranging from 0.02 – 400 grams per square meter and mean average fleet vehicle weight ranging from 1.8-39 megagrams (2.0-42 tons). The equation was also developed using vehicles traveling at speeds ranging from 10-55 miles per hour, although speed is not used in the equation. A particle size multiplier (k) of 0.016 lbs PM10 per VMT is used by URBEMIS2002. This particle size multiplier cannot be changed by the user.

URBEMIS2002 uses the emission factor equation to calculate emissions per vehicle mile traveled. That value is then multiplied by the total vehicle miles traveled per day and by the percentage of vehicles traveling on paved roads

Unpaved Roads

The unpaved road equation is as follows:

$$UNPAVED = (k\ (s/12)^{1.0}\,(S/30)^{0.5})/(\,(M/0.5)^{0.2})$$

Where:

UNPAVED = the fleet average unpaved road dust emissions (pounds/VMT)
k = the fraction of particles less than or equal to the particle size cutoff of 10 microns
s = surface material silt content (%)
S = the average vehicle speed (mph, input by the user)
M = surface moisture content (%)

This equation is based on EPA's emission factor equation for unpaved roads (Environmental Protection Agency 2003b). The following default assumptions are used by URBEMIS2002:

k = 1.8 (for the 10 microns and under particle size cutoff)
s = 4.3 % (allowable range [1.8 - 25.2 %])

S = 40 miles per hour (allowable range [10 - 43 mph])
M = 0.5 % (allowable range 0.03 – 13 %)

Of these default assumptions, all except k can be modified by the user. Once calculated, the emission rate in pounds per vehicle mile traveled is multiplied by the total VMT for the project and then by the percentage of travel on unpaved roads.

Minimize Double Counting for Multiuse Projects and Pass-By Trips

This discussion is divided into two sections: double counting of multiuse projects and double counting of pass-by and diverted link trips.

Double Counting of Multiuse Projects

URBEMIS2002 contains a procedure that reduces double counting of internal trips in a mixed-use project or community plan area. The procedure only applies when at least one residential and one non-residential land use are specified by the URBEMIS2002 user and the user selects the double-counting correction algorithm.

Because trip generation rates account for both trip productions and attractions, adding the gross trip generation for two land uses in a project double counts the trips between them. The procedure described below is designed to count the internal trips only once.

The user has the option of selecting either the direct input of the percentage of internal trips or a program-generated estimate of internal trips. If the user selects the direct input approach, URBEMIS2002 displays a screen showing the number of residential and nonresidential trips. Then the user is prompted to enter the gross internal trip number, which limits the number of internal trips estimated by URBEMIS2002.

The gross internal trip limit reported by the program is based on a comparison of residential trips versus nonresidential trips; the smaller of the two is the limiting value.

Alternatively, the user selects the program-generated estimate of internal trips. Under this option, the user is first asked to identify the project site in relation to its urbanized context.

Suggested default percentages for internal trips by trip purpose are determined by the urbanization context of the project. Usually, the suggested default percentage for work trips is lower than the suggested default percentage for shopping and other trips. The suggested defaults for a major component of a metropolitan area are higher than the suggested defaults for a minor component of a metropolitan area. If the urbanization context of the project is an isolated rural development, the suggested defaults equal 100%. Note that unless residential and nonresidential land uses are perfectly balanced in gross trip generation, there will always be some external trips in the final program computations.

URBEMIS2002 uses the following defaults for performing the double counting adjustment:

Isolated Trip Type	Isolated Development	Minor Component	Major Component
Residential		*percentages*	
Home-Work	100	10	30
Home-Shop	100	20	50
Home-Other	100	20	50
Non-Residential			
Work	100	10	30
Non-Work	100	20	50

As presented above, the proposed double-counting correction is applied only to trips between residential and nonresidential land uses. A small amount of double counting may remain for trips between different residential land uses.

Based on the user's response, URBEMIS2002 presents information internal trip limits based on trip types and prompts the user to estimate the percentage of those trips that are internal to the project (i.e., the percentage that are double counted).

The internal trip double-counting correction procedure is based on the selected land use categories and associated trip generation rates. Residential trips by trip purpose are compared with nonresidential trips by trip purpose to establish limits on the internal trip adjustments.

Once information has been entered in URBEMIS2002, total trips are adjusted by the following formula:

$$\textit{Net Trips} = \text{Gross Total Trips} - (0.5 \times \textit{Gross Internal Trips})$$

This equation can also be presented as follows:

$$\textit{Net Trips} = \textit{External Trips} + \textit{Net Internal Trips}$$

where:

$$\textit{External Trips} = \textit{Gross Total Trips} - \textit{Gross Internal Trips}$$

$$\textit{Net Internal Trips} = (0.5 \times \textit{Gross Internal Trips}).$$

Pass-By Trips

According to the Institute of Transportation Engineers' (ITE) document Trip Generation, 5th Edition (ITE 1991), vehicle trips associated with a trip generator can be divided into three categories:

- *Primary Trips* are trips made for the specific purpose of visiting the generator. The stop at that generator is the primary reason for the trip. For example, a home to shopping to home combination of trips is a primary trip set.

- *Pass-By Trips* are trips made as intermediate stops on the way from an origin to a primary trip destination. Pass-by trips are attracted from traffic passing the site on an adjacent street that contains direct access to the generator. These trips do not require a diversion from another roadway.

- *Diverted Linked Trips* are trips attracted from the traffic volume on roadways within the vicinity of the generator but which require a diversions from that roadway to another roadway to gain access to the site. These roadways could include streets or freeways adjacent to the generator, but without access to the generator.

In calculating the emissions associated with a proposed project, the distinction between these three categories of trips is important. Pass-by and diverted linked trips associated with a proposed project generate substantially lower levels of net emissions than a primary trip.

For air quality impact analysis, the major difference between a pass-by trip and a diverted linked trip is the added vehicle miles traveled associated with the diverted linked trip. Pass-by trips, by definition, do not require a diversion from the original trip route. Conversely, diverted linked trips do involve diversion from the original trip route. A major difficulty in estimating the additional travel associated with a diverted linked trip is that the amount of additional travel is sensitive to local site factors. In particular, the distance from the project site to major arterials or freeways strongly influences the amount of additional travel.

Pass-by and diverted linked trips are most important for retail commercial land uses. As an example of how important these trips are, the February 1995 update to ITE's Trip Generation, 5th Edition, notes that an average of 87% of trips made to gasoline stations in the p.m. peak hour are pass-by and diverted linked trips. Not accounting for pass-by and diverted linked trips substantially overstates the amount of indirect source emissions associated with a proposed gasoline station.

URBEMIS2002 has an option that allows the user to account for pass-by and diverted linked trips. The primary data sources for appropriate pass-by and diverted linked trip adjustments are ITE's Trip Generation, 5th Edition, and the February 1995 update (ITE 1991; ITE 1995). The San Diego Association of Governments (SANDAG) has also produced a document that includes estimates of pass-by and diverted linked trips for specific land uses (SANDAG 1990). These three documents present pass-by and diverted linked trip values as a percentage of total trips for several land use categories. One distinction between the ITE versus SANDAG estimates are that for pass-by trips, SANDAG assumes that any diversion requiring 1 additional mile or less is a pass-by trip. In contrast, ITE assumes that any diversion off of the intended travel route is a diverted linked trip.

Table 3 shows estimates of pass-by and diverted linked trip percentages using data contained in ITE's Trip Generation, 5th Edition, the February 1995 update to the 5th edition, and the SANDAG report (ITE 1991, ITE 1995; SANDAG 1990). The ITE and SANDAG trip generation data primarily describe peak-hour versus average daily conditions. Jones & Stokes Associates has developed average daily percentages of primary trips, diverted-linked trips and pass-by trips associated with each land use for the URBEMIS2002 model.

When the pass-by trip correction algorithm is selected by the user, URBEMIS2002 adjusts trip end emissions (i.e., cold start, hot start, and hot soak) associated with pass-by and diverted linked trips

For traffic impact analyses, pass-by trips are generally eliminated from consideration; they have no net effect on traffic volumes. Similarly, diverted linked trips may have a minimal effect on traffic volumes. Conversely, pass-by and diverted linked trips may have a substantial effect on air quality, and this effect may increase in the future as trip end emissions become a larger portion of total vehicle trip emissions. A pass-by or diverted linked trip associated with a shopping center is a good example of how these trips can affect air quality. Such a trip would have little or no net effect on traffic volumes. However, if the shopper stays at the shopping center for 1 hour, a substantial portion of a hot soak episode would occur and, for a catalytic converter-equipped vehicle, the trip leaving the shopping center would begin in a cold-start mode.

URBEMIS2002 estimates trip end emissions associated with pass-by and diverted linked trips and additional travel associated with diverted linked trips. Jones & Stokes Associates has modified URBEMIS2002 so that it makes separate emission estimates for primary trips, pass-by trips, and diverted-linked trips.

For primary trips, the emission estimating procedure do not change except that the trip generation rate for each land use would be multiplied by that land use's primary trip percentage shown in Table 3.

For pass-by trips, the trip generation rate for each land use are multiplied by that land use's pass-by trip percentage shown in Table 3. In addition, the trip length for each trip type (e.g., home-work, home-shop) is set to 0.01 miles. The change in trip length reflects the pass-by trip definition in that these trips result in virtually no additional travel. However, emissions associated with pass-by trips still occur. Consequently, the hot and cold start percentages are increased by 10 percent to reflect additional emissions from these operating modes.

For diverted-linked trips, the trip generation rate for each land use is multiplied by that land use's diverted-linked trip percentage shown in Table 3. The trip length is also adjusted downward to equal 25 percent of the primary trip length for each trip type. By doing so, it accounts for the additional travel associated with diverted-linked trips. Also, the hot and cold start percentages for each trip type are increased by 10 percent to reflect additional emissions from these operating modes.

Method for Calculating Default Trip Lengths from Travel Survey Data

Trip lengths are one of the most important data elements used in calculating project emissions. Air districts or other agencies responsible environmental review should ensure that default trip length values used in their area have a sound basis. Unfortunately, the data most readily available from regional travel models for this purpose is typically formatted differently than is used in URBEMIS. This section provides a method for converting available data for use as URBEMIS2002 defaults.

One source of data is the Caltrans Statewide Travel Survey. The most recent version was published in 1991. The data is stratified by trip purpose. The trip categories are home to work (H-W), home to shop (H-S), home to other (H-O), other to work (O-W), and other to other (O-O). The survey provides trip lengths for only H-W and total trips. More detailed breakdowns may be available from the Regional Transportation Planning Agency in your area. The survey and most RTPA models provide trip lengths in terms of minutes. The average speed is used to convert minutes to miles.

The H-W, H-S, and H-O trip lengths can be used directly in URBEMIS. However, for non-home based trips, URBEMIS uses work (W) and non-work (N-W) trips when analyzing all non-residential projects (commercial, industrial, institutional, etc). To produce work-related trip lengths for non-residential projects analyzed in URBEMIS, a composite work trip length is calculated that is a composite of H-W and O-W trip lengths. For URBEMIS, non-work trips are a composite of H-S, H-O, and O-O trip lengths. Both are based on the relative occurrence of the individual trip types.

The following table illustrates this concept using Southern California data as an example:

Travel Survey Trip Types:	**H-W**	**H-S**	**H-O**	**O-W**	**O-O**	**Total**
Percent trip type:	20%	9%	43%	11%	17%	100%
Trip length in minutes:	19.63	7.91	9.58	15.06	8.96	
Trip length in miles:	11.5	4.87	6.02	9.07	5.66	

URBEMIS non-residential Work trip lengths = composite of H-W + O-W
URBEMIS non-residential Non-Work trip lengths = composite of H-S + H-O + O-O

Work Trip Length Formula:

(%H-W / (%H-W + %O-W) x H-W TRIP LENGTH) +

(%O-W / (%H-W + %O-W) x O-W TRIP LENGTH)

Non-Work Trip Length Formula:

(%H-S / (%H-S + %H-O + %O-O) x H-S TRIP LENGTH) +

(%H-O / (%H-S + %H-O + %O-O) x H-O TRIP LENGTH) +

(%O-O / (%H-S + %H-O + %O-O) x O-O TRIP LENGTH)

Example Calculation Using South Coast Data:

Commute Trip (W)

(20%/(20%+11%) X 11.5 mi.)+ (11%/(20%+11%) X 9.07 mi.) = 10.6 mile W trip

Non-Work Trip (N-W)

(9%/(9%+43%+17%) X 4.87 mi.) + (43%/(9%+43%+17%) X 6.02 mi.) +
(17%/(9%+43%+17%) X 5.66 mi.) = 5.78 mile N-W trip

Default Values for Emission Calculations

Diurnal Soak Hours per Day: 7.1

Resting Loss Hours per Day: 12.9

Vehicles per Household: 1.8

Appendix C References

Institute of Transportation Engineers. 1991. Trip generation. 5th edition, Washington, DC.

Institute of Transportation Engineers. 1995. Trip generation February 1995 update to the 5th edition. Washington, DC.

California Air Resources Board. 1997. Emission inventory procedural manual volume III methods for assessing area source emissions. Sacramento, CA. 1997.

San Diego Association of Governments. 1990. San Diego traffic generators. California Department of Transportation, District 11. San Diego, CA.

U.S. Environmental Protection Agency. 2003a. Draft of October 2001 unpaved road emission factors: Website: http://www.epa.gov/ttn/chief/ap42/ch13/draft/d13s02-2_oct2001.pdf

U.S. Environmental Protection Agency. 2003b. 2002 paved road emission factors: Website: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s02-1.pdf

Appendix D. URBEMIS2002 Mobile Source Mitigation Component

Mobile Source Mitigation Component

Background

The purpose of this appendix is to document the basis of the emission reduction quantification system used in the URBEMIS 2002 Mobile Source Mitigation Component (Component). It also describes how the various parts of the Component work together to determine project level emission reductions.

The Component is a tool for quantifying emission reductions achievable by development projects under a wide range of conditions. It uses a two step process. The first step creates "environmental factors" to take into account the effects of existing and planned development and transportation infrastructure near the project site on trip generation at the project site. The second step allows selection of specific measures that will result in emission reductions for projects. The Component then applies the factors set in step one to the mitigation measures selected in step 2 and arrives at a percent reduction in trips and reductions in vehicle miles traveled. The URBEMIS program then translates these trip and VMT reductions into emission reductions.

Research related to factors affecting vehicle travel found that neighborhood level trip generation and vehicle miles traveled vary by as much as fifty percent in California cities (JHK and Associates, 1995a). The primary factors cited for the variation were density, mix of uses, proximity of uses, transportation systems, and access. Areas with low trip generation and VMT levels and the greatest transit use and pedestrian activity also had the highest densities, a wide variety of uses within walking distance, safe and comfortable pedestrian access, paid parking requirements, and a high level of transit service. Areas with the highest trip generation and VMT levels had low development densities, strict separation of land uses, poor pedestrian access between land uses, abundant free parking, and poor transit service. Use of bicycles varied by orders of magnitude in different cities but the differences were due primarily to access and safety considerations. The Component uses this information to determine a variable credit for applying mitigation measures to development projects.

The Component estimates trip reduction relative to Institute of Transportation Engineers (ITE) Trip Generation rates for a particular land use. ITE trip generation data are primarily obtained from counts of the number of motor vehicles entering and leaving driveways at a project site. A number of studies of similar land uses are conducted and the results are statistically manipulated to obtain the trip generation rate. People walking, bicycling, and using transit for their trips are not counted. This is significant because as was described earlier, a project's setting can dramatically affect the share of trips absorbed by transit, bicycling, and walking, and the overall trip generation rate. The Component attempts to use a project's environmental setting and mitigation measures to estimate the percentage of trips that will be diverted to these alternative modes of transportation compared to the averages used by ITE.

BASIS AND DESCRIPTION OF COMPONENT ENVIRONMENTAL FACTORS

Introduction

The Component contains a series of screens requiring the user to set environment factors in three categories: pedestrian, transit, and bicycle. These factors are used later to determine the effectiveness of infrastructure and design based mitigation measures. The environmental factors provide a sliding scale that allows a project's trip generation to reflect levels achieved at real world locations having similar conditions.

Pedestrian Environment

The pedestrian environment factor (PEF) is set by grading a project in each of seven factors. Each factor allows the user to select one of three possible scores or to skip the factor and assign a score of zero. The factors are weighted by setting the maximum possible score at between 2 for the least important factors and 5 for the most important factor. The weighting is based on review of the literature on walking and pedestrian enhancement. It uses concepts developed by Holtzclaw for the Bay Area (Holtzclaw, 1994) and work done for the LUTRAQ project in Portland, Oregon (1000 Friends, 1996). The seven different factors used in determining the PEF are listed in Table D-1.

TABLE D-1
Pedestrian Environment Point Ranges

Factor	Score Range in Points
Mixture of Uses To Attract Pedestrians Within Walking Distance These factor is not included here in the model.	0-5
Sidewalks and Pedestrian Paths	0-3
Pedestrian Circulation Provides Direct Access	0-3
Street Trees Provide Shade Canopy	0-2
Street System Designed to Enhance Pedestrian Safety	0-2
Pedestrian Routes Provide Safety from Crime	0-2
Walking Routes to Important Destinations Provide Visual Interest	0-2
TOTAL POINTS POSSIBLE	19

Program users score the project being analyzed based on the environment within one mile of the project site. A one mile walking distance is based on maximum walking trip lengths described in the National Bicycling and Walking Study (Case Study 3). For small projects, the analysis would be based primarily on land beyond the project boundary. For large self-contained projects, the analysis would be based mostly on the internal design of the development. Since every project site is different, user judgement is required for determining the analysis boundary.

The heaviest weighted feature is the mixture of uses within walking distance. Without destinations to walk to, all other features only enhance recreational walking. Distance comes into play again on pedestrian circulation providing direct access. With most people being unwilling to walk more than 1/4 mile (Cervero, 1994) anything that creates barriers to pedestrian access and makes trip distances longer will discourage walking. Several features are listed that enhance pedestrians' comfort and safety during the walking trip. When routes are safe and attractive, pedestrians will walk longer distances, thus widening the range of potential trip destinations for a greater number of people.

The PEF is calculated by adding the scores for each factor and dividing the total by the maximum possible score. For example, a project that scores 12 of the possible 19 points would earn a PEF of 12/19 = .63. This is accomplished as an internal program calculation.

Transit Environment

The transit environment selection screen uses a 0-100 point scale for rating system effectiveness. The end points of the scale are anchored with dial-a-ride service at 0 and urban heavy rail service within 1/2 mile (BART) at 100. Intermediate data points between these two types of service were determined using two 1994 studies by Cervero (*Transit-based Housing in California: Evidence on Ridership Impacts* and *Rail-Oriented Office Development in California: How Successful?*) The studies provide mode share data for heavy rail, commuter rail, and light rail systems in California. The studies also provide mode shares for development near transit and on a regional basis.

Bus service levels were based on mode shares achieved by urban and suburban bus services in California. More suburban cities with relatively poor fixed route bus service have about a one percent transit mode share (U.S. Census, 1990).

The transit environment uses a distance decay factor to determine the relative effectiveness of light rail at 1/4 and 1/2 mile. The highest mode shares were achieved by developments within 1/4 mile of the light rail station. Using a distance decay factor of 0.85 percent per 100 feet (Cervero 1994), an additional 1,320 feet (1/4 mile) would result in an 11 percent reduction in effectiveness.

No credit is given for transit beyond 1/2 mile for rail and 1/4 mile for bus service. These distances are based on limits most people are willing to walk (Cervero, 1994). Beyond 1/2 mile from rail, most people drive or use bus transit to get to the train station. Except in very urbanized areas, the number of people using a bus to get to rail transit is quite small. Because of cold start and hot soak emissions, the air quality benefit of people driving to rail is limited to the vehicle miles traveled (VMT) reduced by not driving the full distance. Its effects are more akin to those of a park and ride lot. Dial-a-ride services are considered 0 because they provide transportation for trips that would in most cases not have been made or would have been made by carpooling.

To account for the effect of the pedestrian environment on people's ability to walk to the transit stop or station, the Component uses a pedestrian accessibility adjustment (PAA). The PAA uses the pedestrian environmental factor (PEF) obtained in the previous screen. If the pedestrian environment is poor, fewer people will be willing to walk to the station, even if close. If the pedestrian environment is good, people will be encouraged to walk to the station or transit stop. The PAA is based on an assumption that transit use can be influenced by up to 10 percent by the pedestrian environment. This number is somewhat modest to reflect Cervero's 1994 finding that proximity and parking availability at the destination dominate other factors affecting transit.

After the level of transit service and the pedestrian environment have been set, the program calculates a transit environment factor (TEF) between 0 and 1. The TEF is based on the score achieved divided by the total possible score. For example, light rail within 1/2 mile is worth 40 points. If the project had an outstanding pedestrian environment factor of 1, the pedestrian adjustment is (10 % * 40 x 1 = 4 points) The total score is then 44 out of a possible 110 and 44/110 = 0.4. A factor of 0.4 means that a project in this environment may achieve 40 percent of the maximum possible trip reduction for transit.

Bicycle Environment

The bicycle environment factor (BEF) selection screens list 6 different factors affecting how much people will bicycle for purposes other than recreation. Bicycle distance for all measures is set at 5 miles based on the maximum cycling distance described in *The National Bicycling and Walking Study Case Study 4* (U.S. Department of Transportation, Federal Highway Administration, 1993). As with the PEF, each feature's points are weighted, in acknowledgment that some features are more important than others. The 6 features and their scoring ranges are listed on Table D-2. The BEF is calculated in the same manner as the PEF.

The bicycle environment factor (BEF) utilizes other information from *The National Bicycling and Walking Study Case Study 4* to determine and weight factors affecting bicycle use. The weighted factors are based on surveys of what bicycle riders believe was preventing them from using a bicycle for transportation. The primary factors are directly or indirectly related to safety. The more safe and secure bicyclists feel as they ride, the more likely they are to use bicycles for transportation. The second most important consideration is distance. Since most bicycle trips are less than 5 miles in length and the average is around 2.5 miles, without a good mixture of uses within bicycling distance on safe routes, few people will choose to use a bicycle. Schools, particularly colleges and universities, are major contributors to bicycle mode shares. University towns like Davis and Palo Alto have very high bicycling rates. The final factor is secure bike parking at the destination.

TABLE D-2
Bicycle Environment Point Ranges

Factor	Score Range in Points
Area Served by Interconnected Bikeways	0-5
Bike Routes Provide Wide Paved Shoulders and Few Curb Cuts	0-3
Speed Limits of 30 MPH or Less on Streets with Bike Routes	0-2
Schools with Safe Routes	0-5
Mixture of Uses to Attract Bicyclists within Easy Cycling Distance	0-3
Community Has Bike Parking Ordinance	0-2
TOTAL POINTS POSSIBLE	20

BASIS and DESCRIPTION of the MITIGATION MEASURE SELECTION and QUANTIFICATION SYSTEM

Introduction

In the second step of the process, the user selects measures from a series of screens: transit, pedestrian and bicycle infrastructure, operational measures, and vehicle miles traveled reduction measures. Separate screens are provided for residential and commercial measures with the option available for viewing either or both sets of measures. Separate commercial and residential screens allow the program to credit measures to the appropriate trip types. The three sets of infrastructure based measure screens (transit, pedestrian, and bicycle) have a section referred to as "project description measures." These measures allow trip reduction percentages to be credited to a project even when a project applicant provides no formal mitigation measures. It allows better prediction of trip generation rates without applying unrealistically high benefits to individual measures. More discussion of project description measures is provided later.

Program users select measures appropriate for their project and the screen displays the maximum percent trip reduction possible. These numbers are later reduced by the environment factors determined in step 1 to ensure that the trip reduction credited is as accurate as possible.

The emission reduction percentages for individual infrastructure measures and operational measures are taken from trip reduction estimates from CEQA guidelines used by several California air pollution control districts, including South Coast, Sacramento, Bay Area and Monterey Bay.

The program allows the user to add measures not listed on the measure screens. The amount of credit allowed, however, is limited to a maximum amount allowed for each type of measure (transit, bicycling, etc.). So, for example, if an applicant identifies a bicycling measure not listed on the screen, the total amount of credit cannot exceed 9 percent. When more than 9 percent is listed, the program displays an error message. This is to prevent the program user from showing reductions beyond what is feasible to achieve.

Project Description Measures

Each infrastructure measure selection screen contains one to three "project description measures." The first measure in each case is a credit for pedestrian, transit, or bicycle environment. The concept can be explained with an example. An apartment complex is proposed for a site 1/4 mile from an existing light rail station. Future tenants of the complex are much more likely to use light rail than the average person yet the developer has no need or ability to provide transit supporting infrastructure since it already exists. Therefore, a mechanism was needed to recognize the trip reduction benefit of the decision to develop at that particular site. Thus, the credits for environment were devised. The amount of the credit was set at a level that would allow a project with the best possible environment and all feasible infrastructure measures to achieve mode shares found in the literature for similar projects. Since most projects fall well below the best, the environment factor is applied to the total to provide a comparison of a particular site with the best. The credit for environment is not a user selection. As long as the environmental factors are greater than zero, some credit is given to each project.

The second types of project description measures are user selected. These are different for each infrastructure measure screen. The transit screen includes a credit for project density meeting transit level of service requirements. The pedestrian screens include a credit for residential and commercial mixed use projects and for commercial projects with high floor area ratios (FAR). These credits are used in the system devised by JHK & Associates for the Oregon Department of Environmental Quality (JHK & Associates, 1995b). The bicycle screen contains no additional credits.

Transit Mitigation

For transit, the maximum achievable reduction has been set at 25 percent, based on the Cervero 1994 rail studies. This reduction is based on a 25 percent transit mode share in urban residential developments within walking distance of a BART station. Most of this potential reduction is due entirely to the developer's decision to locate near an existing or planned transit system. For this reason 15 percent of the possible 25 percent reduction is given as a credit for existing or planned community transit service. This number may seem high, but it will be reduced by the TEF in the next step.

The second measure, included as part of the project description is density. If project density is greater than or equal to the density standards needed to support the type of transit serving the site, 6 percentage points are awarded. Projects not meeting density standards degrade transit service and so are not awarded any points. Density standards are based on numbers developed by the State of Florida (Table D-3) and by Pushkarev and Zupan (Table D-4).

TABLE D-3
Transit Related Density Standards

Mode of Transit	Level of Service	Minimum Necessary Residential Density (Dwelling Units Per Acre)	Other Characteristics
Dial-A-Bus	Many Origins/Destinations	6	Only if labor costs are not twice those of taxis.
Dial-A-Bus	Fixed Destination or Subscription Service	3.5 to 5	Lower figure if labor costs are twice those of taxis; higher if thrice.
Local Bus	Minimum 1/2 Mile Route Spacing, 20 Buses Per Day	4	Average varies as a function of downtown size and distance from residential area to downtown.
Local Bus	Intermediate - 1/2 Mile Route Spacing, 20 Buses Per Day	7	
Local Bus	Frequent - 1/2 Mile Route Spacing, 120 Buses Per Day	15	
Express Bus - Reached on Foot	Five Buses During Two-Hour Peak	15 - Average Density Over Two Mile Area	From 10 to 15 miles away to largest downtowns.
Express Bus Reached by Auto	Five to Ten Buses During Two-Hour Peak	3 - Average Density over 20 Square Miles	From 10 to 20 miles away to downtowns large than 20 million square feet of non-residential floor space.
Light Rail	Five-Minute Headways or Better During Peak	9 - Average Density for Corridor of 25 to 100 Square Miles	To downtowns of 20 to 50 million square feet of non-residential floor space.
Rapid Transit	Five-Minute Headways or	12 - Average	To downtowns larger than 50

	Better During Peak	Density for Corridor of 100 to 150 Square Miles	million square feet of non-residential floor space.
Commuter Rail	20 Trains Per Day	1-2	To CBDs with rail.

Source: *Florida Statewide Transit System Plan, Phase III, Development of State Transit Standards*, October 1988.

TABLE D-4
Minimum Residential Densities to Support
Different Levels of Transit Service

Mode of Transit Service	Frequency	Minimum Density DU/Res Acre
Frequent Bus Service	Every 10 minutes, 20 hours per day - 120 buses/day 1/2 mile spacing over area	15
Rapid Transit (Heavy Rail)		12
Light Rail (Street car, radial corridors)		9
Intermediate Bus Service	1/2 hourly, 20 hours per day - 40 buses/day	7
Minimal Bus Service	½ hourly, 10 hours per day or hourly, 20 buses per day	4
Commuter Rail on Existing Track		2

Source: JHK & Associates, 1995a.

The remaining 4 possible percentage points are awarded for infrastructure measures to be provided by the developer. The measures are assigned reductions ranging from 0.5 to 2 percent based on their relative contributions to making transit use more convenient and comfortable. These percentages are taken from trip reduction estimates in CEQA guidelines used by several California air pollution control districts.

If we return to our project served by light rail with the excellent pedestrian environment, and the developer provides the density and all infrastructure measures, then the actual percent trip reduction would equal 25 percent x 0.4 TEF = 10 percent reduction. We would expect 10 percent of work trips to be captured by the light rail system. This number is consistent with Cervero’s findings for mode shares for residential development 1/2 mile from light rail.

Pedestrian Mitigation

Pedestrian mitigation measures are presented on 2 screens: residential projects and non-residential projects. The maximum achievable reductions have been set at 9 percent for residential projects and non-residential projects. The maximum reductions are derived mainly from an analysis of Bay Area travel surveys (Fehr and Peers, 1992). This study provides mode shares for traditional versus suburban neighborhoods. Non-home-based trips in traditional neighborhoods achieve up to a 9 percent increase in pedestrian mode share over standard suburban development (see Table D-5). Oregon’s LUTRAQ study (1000 Friends, 1996) contains pedestrian mode share information that confirms the Fehr and Peers information (see Table D-6). Walk/bike mode share in TODs for “home-based other trips” (HBO) is 12.8 percent compared to 3.3 percent for the no build alternative. Total home-base non-work (HB N-W) is 20.7 percent for TODs compared to 6 percent for the no build alternative. Other trip types show similar reductions. The bottom level for pedestrian travel approaches zero in very low-density suburban or rural settings. Some projects may have no destinations within walking distance.

TABLE D-5
Trip Differences Between Traditional and Suburban Bay Area Neighborhoods for Walking Trips

Trips	Traditional Neighborhoods (percent)	Suburban Neighborhoods (percent)	Differences (percent)
Home Based Work	4	3	1
Home Based Non Work	14	10	4
Work Based Other	15	8	7
Non Home Based Trips	17	8	9
All Trips Combined	12	8	4

Source: Based on Fehr and Peers. *Metropolitan Transportation Commission Bay Area Trip Rate Survey Analysis, Oakland, CA.* MTC, 1992.

TABLE D-6
Walk/Bike Mode Choice from LUTRAQ
(by percentage of trip type)

Trip Type	No Build Alternative	LUTRAQ TOD Only (adj.)	Difference
Home Based Work	2.8	6.1	3.3
Home Based Non-Work	6	20.7	14.7
Total Home Based	5.1	17.2	12.1
Non-Home Based Work	.4	13.1	12.7
Non-Home Based Non-Work	.3	10.2	9.9
Total Non-Home Based	.3	11.4	11.1
Total All Trips	3.8	15.6	11.8

Source: 1000 Friends of Oregon, 1996.

Work-based customer trips achieve very high pedestrian mode shares in high-density downtown settings compared to suburban settings. ARB's shopping center study (JHK & Associates, 1993) found that regional shopping centers in two California low-density suburban settings had pedestrian mode shares of 0.7 and 1.6 percent (See Table D-7). A shopping center in a high-density suburban setting had a 21.7 percent pedestrian share and another in a high-density urban setting had a 28.9 percent share.

Although the pedestrian mitigation screens allow a maximum trip reduction of 9 percent, operational measure screens account for other trips reduced. For example, an additional reduction of up to 10 percent may be added on the operational measures screen if the employees and customers must pay for parking. This parking credit is included in the operational measures section because it increases all alternative mode use, not just walking. Two percent of the possible 9 percent is given as a credit for the surrounding pedestrian environment, 1 percent is awarded if the project is a commercially oriented mixed use project, and an additional 1 percent if its floor area ratio is 0.75 or greater.

TABLE D-7
Walking Mode Shares in California Regional Shopping Centers
(Percent)

Suburban Low-Density 1	Suburban Low-Density 2	Suburban Medium-Density	Suburban High-Density	Urban High-Density
0.7	1.6	19.3	21.7	28.9

Source: JHK & Associates for California Air Resources Board. *Analysis of Indirect Source Activity at Regional Shopping Centers, Final Report A132-094*. November 1993.

For residential projects, 2 percent of the possible 9 percent, is allotted as a credit for the surrounding pedestrian environment and an additional 3 percent is awarded if the project is a residentially oriented mixed use project. The remaining 4 possible percentage points for residential projects and 5 points for non-residential projects are awarded for infrastructure measures to be provided by the developer. The measures are assigned reductions ranging from 0.25 to 1 percent based on their relative contributions to making pedestrian travel more safe, comfortable, and convenient. These numbers are generally based on percentages used in the air district CEQA guidelines referred to earlier.

Bicycle Mitigation

Bicycle mitigation measures are presented on 2 screens: residential projects and non-residential projects. The range in trip reduction effectiveness for bicycles is very broad. In Davis, bicycling captures about 25 percent of work trips. In Palo Alto, about 10 percent of all trips are accomplished by bicycle (U.S. Department of Transportation, Federal Highway Administration, 1993). At the bottom of the scale, many cities achieve less than 1 percent bicycle mode share. For both residential and non-residential projects, the maximum achievable mitigation credit was set at 9 percent to reflect a level of improvement from the typical 1 percent to the outstanding 10 percent achieved by Palo Alto. Davis was not used as the maximum because it would skew the percent trip reductions excessively high. Although possible to recreate the environment and bicycle infrastructure that led to Davis' high bicycle mode share, the attitude of local residents toward bicycling would take many years to cultivate.

The remaining 2 possible percentage points for residential projects and 4 points for non-residential projects are awarded for infrastructure measures to be provided by the developer. The measures are assigned reductions ranging from 1 to 2 percent based on their relative contributions to making bicycle travel safer, and more comfortable, and convenient.

Operational Measures

Operational mitigation measures are divided among three screens based on the type of trip impacted. The first set of measures apply to commute trips. These include some measures that may be provided by an employer and other measures that may be obtained from other service providers or that take advantage of the existing built environment. Examples of the former are a compressed work schedule and preferential carpool parking. Examples of the latter are an office built in an area with limited, paid parking not owned or leased by the employer. The second set of measures apply to employee shopping trips and errands. Some measures have the employer provide services at the employment site that employees would normally have to use a car to obtain. The second strategy is to provide alternative transportation in the form of a shuttle to lunch and shopping areas out of walking range of the employment site. The third set of measures apply to customer and client trips. The only measure listed in this case is paid parking.

The percentage reductions used for the operational measures were taken from CEQA Guidelines used by several California air pollution control districts. Use of compressed work schedules provides up to a 40 percent reduction for businesses having 100 percent of their employees on a 3/36 work schedule (3 days/week, 12 hours/day). Charging for parking is the next most effective measure, allowing up to a 10 percent reduction in areas with high daily parking charges.

Measures Reducing Vehicle Miles Traveled (VMT)

The final set of screens include measures that usually do not reduce vehicle trips, but do reduce VMT. The two measures included are park and ride lots and satellite telecommuting centers. These could either be provided by or in proximity to a residential development or by a commercial development.

The input screen for these measures require the user to provide the number of people that can use the facilities. For, example, on any given day a park and ride lot with 100 spaces can be used by 100 drivers. The number of spaces is then multiplied by 89 percent to account for the average portion of the trip driven by private vehicle to the park and ride lot or to the telecommuting center (Monterey Bay UAPCD, 1995). Currently, the program assumes 100 percent use of the facility. This may be reduced based on local conditions. For telecommuting measures, the program assumes that facilities will be used by employees two days per week. If a business allows telecommuters greater or lesser use, the percent employees participating can be adjusted to reflect the actual trip reduction benefit. For example, if 10 percent of employees are telecommuting 5 days per week, the percent employees should be adjusted from 10 to 25 percent to compensate for the higher days per week. If 10 percent of all employees are telecommuting only 1 day per week, the percent should be adjusted to 5 percent.

Another potential measure not currently listed on the VMT measure screen is rail station parking. Developments in communities served by rail, but farther than one half mile from a rail station will achieve reduction in VMT not accounted for in the transit screens discussed earlier. Using BART as an example, 5.5 percent of station area residents drove to the station compared to 80 percent of all suburban Bay Area residents (Cervero, 1994). Using citywide work trip mode splits for BART of 4.4 percent for Hayward, and the 80 percent drive to station statistic, VMT reduction would apply to 4.4% x 80% = 3.5% for suburban communities served by BART. Therefore, a development generating 100 work trips in a community with a BART station would reduce VMT by 3.5 trips x average trip length for work trips (10 mi.) x trip length driven to the station (5 miles) divided by the total home to work trip length (10 mi.) = 35 miles.

The calculation methodology is as follows:

$$\frac{RTMD \times \%DTS \times AWTL \times H\text{-}SATL}{H\text{-}WATL \times \#PWT} = MS$$

RTMD = Citywide mode share for rail transit
%DTS = percent expected to drive to the station
AWTL = average work trip length
H-S ATL = average trip length from home to station
H-WATL = average trip length home to work
#PWT = number of work trips for the particular project
MS = miles saved by rail transit system.

The number of work trips can be obtained from URBEMIS. For example, for a residential development in Sacramento, 27.8 percent of trips are home to work trips. Each residence generates 9.6 trips per day, so .278 x 9.6 = 2.7 work trips per residence. A 100 unit residential development would generate 270 work trips.

If data are available for all trip types, they may be used to calculate VMT reductions from all trips instead of just the commute trip. The example used above is based on work trips because rail mode split data were located for only work trips.

CORRECTION FACTORS

Trip Type Correction Factors

URBEMIS 2002 calculates emissions based on six trip types. Home based trip types are home to work (H-W), home to shop (H-S), home to other (H-O). Trips for commercial land uses include work trips (W), non-work employee trips (N-W-Emp), and non-work customer trips (N-W Cust). A number of studies show that certain trip types are more likely to be captured by one mode rather than another. The calculation procedure uses a correction factor to account for these differences. Trip type correction factors are provided in Table D-8.

TABLE D-8
Trip Type Correction Factors

	H-W	H-S	H-O	W	N-W Emp	N-W Cust
Transit	1.0	.22	.27	1.0	.02	1.0
Pedestrian	.11	.44	.44	.11	1.0	1.0
Bicycle	1.0	1.0	1.0	1.0	1.0	1.0

Source: Cervero, 1994a, 1994b and JHK & Associates, 1993.

The commute trip is most likely to be made using transit while shopping trips are the least likely to be made by transit. To determine the correction factor, the best trip type was set equal to one (1). To determine the correction factors for the other trip types their mode shares were divided by the mode share of the highest trip type. For example, if the home to work mode share is 19 percent and the home to shop mode share is 4.1 percent, then the correction factor is 4.1%/19% = 0.22. The correction factor is then multiplied by the trip reduction achieved on the mitigation measure screen to account for the lower effectiveness for this type of trip. For the light rail example previously discussed, work trips achieve a 10 percent reduction, but home to shopping trips achieve reduction of 10 percent x 0.22 = 2.2 percent. The correction factor for transit was derived from Cervero's 1994 survey data for work trips, shopping trips, and other trips for all rail systems in the study.

The correction factor for non-work employee trips was taken from Cervero 1994a. Cervero found that only two percent of people who commuted by rail transit used rail for their midday trips.

Non-work customer trips provide an additional challenge. In an urban setting well served by a regional transit system, 32.5 percent of shoppers arrived by transit to a regional shopping center (JHK and Associates 1993). However, we would expect other commercial developments and service based offices to attract fewer transit riders. Therefore the correction factor was set at 1.0 pending receipt of data on these other types of developments.

Bicycle trip reduction percentages are based on overall trip reduction and not on trip reduction for each trip type. This means that no trip type correction factors are needed. If trip type data are available for bicycling, the program has the capability to use them.

Trip Distance Correction Factors

Trip distance correction factors are needed to account for the fact that bicycle and walking trips replace mostly shorter automobile trips. Trips accomplished by bicycling or walking are reducing less emissions than would be generated using the average vehicle trip lengths used in URBEMIS. This is complicated by cold start and hot soak emissions that are generated by both long and short trips. The longest trips are work trips. In most jurisdictions the work trip now exceeds 10 miles. With the average walking trip at one-half mile, five percent of the running emissions of the average work trip would be reduced plus cold start and hot soak emissions. For home to shopping trips the average trip length is about 5 miles. So, for H-S trips about 1/10 (1/2 mile walk/5 mile drive) of the running emissions would be reduced. For bicycling the average trip length is 2.5 miles; therefore, the correction factors are higher than for walking.

Table D-9 contains the percent of emissions reduced by bicycling and walking trips for two trip distances. The trip distance correction factor is currently based only on ROG.

TABLE D-9
Comparison of Emissions from Trips Replaced with Walking and Bicycling
(Percent)

	ROG	NOx	CO	PM-10
.5 mi. Walking/5 mi. Car Trip	60	23	46	10
.5 mi. Walking/10 mi. Car Trip	42	12	29	5
2.5 mi. Bike/5 mi. Car Trip	78	57	70	50
2.5 mi. Bike/10 mi. Car Trip	54	31	44	25

Note: Comparison of emissions generated by 100 unit residential subdivision generating 1030 trips using all defaults except trip length for a summer run in URBEMIS 2002. Separate runs were done for .5, 2.5, 5.0, and 10 miles.

The trip distance correction factors (see Table D-10) were estimated using an average trip length for automobiles of 5 miles for home to shopping, home to other, and non-work commercial based trips and 10 miles for commute trips. The pedestrian trip length was set at one-half mile and the bicycle trip was set at two and one-half miles based on information from the *National Bicycling and Walking Study*.

TABLE D-10
Trip Distance Correction Factors for ROG

	H-W	H-S	H-O	W	N-W Emp	N-W Cust
Pedestrian	.42	.60	.60	.42	.60	.60
Bicycle	.54	.78	.78	.54	.78	.78

Source: URBEMIS 2002 Ver.7.2.4

Future upgrades to URBEMIS could provide correction factors for each pollutant based on trip lengths input by the user or the air district. Jurisdictions with short average trip lengths will tend to have higher correction factors since more trips will be within walking and cycling distance. The calculation method would be as follows:

1. Determine average trip lengths for each trip type used by URBEMIS.

2. Determine average trip lengths for bicycling and walking if different than default values.

3. Perform URBEMIS runs for each trip length, setting one trip type equal to 100 percent and others equal to 0 percent.

4. Determine the ratio for each trip type and each pollutant by dividing the total emissions for the walking trip distance by the total emissions for each trip type. For example, emissions using walk trip distance/emission using home to work trip distance.

5. The ratios obtained are the trip length correction factors that will then be applied to the trip reduction percentages for each pollutant.

This may be a programming challenge because the program currently calculates emission reductions based on trip and VMT reductions, not on emission reductions by pollutant.

LIMITATIONS OF THE MITIGATION COMPONENT

The URBEMIS 2002 mitigation component is a significant advance over past attempts to quantify the benefits of air quality mitigation measures, however, users should recognize that travel behavior is very complex and difficult to predict. The component relies on the user to determine factors critical to travel behavior that are somewhat subjective. As GIS and electronic traffic monitoring and data collection become a reality in many cities, the ability to identify factors critical to walking, bicycling, and transit use will be enhanced. The URBEMIS 2002 mitigation component provides a starting point for using currently available data to demonstrate the benefits of urban design and traditional mitigation measures in reducing air quality impacts.

Appendix D References

1000 Friends of Oregon. *Making the Land Use Transportation Air Quality Connection, Analysis of Alternatives, Volume 5. May 1996.*

Bay Area Air Quality Management District. *CEQA Guidelines Assessing the Air Quality Impacts of Projects and Plans.* 1996.

Cervero, Robert. *Transit-Oriented Office Development in California*. How Successful? 1994a

Cervero, Robert. *Transit-Based Housing in California: Evidence on Ridership Impacts*. *Transport Policy* 3: 174-183. 1994b.

Fehr and Peers. *Metropolitan Transportation Commission Bay Area Trip Rate Survey Analysis, Oakland, CA.* MTC, 1992.

Florida Statewide Transit System Plan, Phase III, Development of State Transit Standards, October 1988.

Holtzclaw, John. June 1994. *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*. Natural Resources Defense Council.

JHK & Associates for California Air Resources Board. *Analysis of Indirect Source Activity at Regional Shopping Centers, Final Report A132-094*. November 1993.

JHK & Associates for California Air Resources Board. *Transportation-Related Land Use Strategies to Minimize Motor Vehicle Emissions: An Indirect Source Research Study*. June 1995a.

JHK & Associates for Oregon Department of Environmental Quality. *Alternatives to Single Occupant Vehicle Trips, Final Report.* June 1995b.

Middlesex-Somerset-Mercer Regional Council (MSM). "The Impact of Various Land Use Strategies on Suburban Mobility." FTA-NJ-08-7001-93-1. December 1992.

Monterey Bay Unified Air Pollution Control District. *CEQA Air Quality Guidelines.* October 1995.

National Cooperative Highway Research Program (NCHRP), Transportation Research Board. "Travel Characteristics at Large-Scale Suburban Activity Centers," Report #323, prepared by K. G. Hooper, JHK & Associates, Alexandria, VA March 1989.

Sacramento Metropolitan Air Quality Management District. *Indirect Source Review Program Implementation Guidelines.* February 1995

South Coast Air Quality Management District. *CEQA Air Quality Handbook.* April 1993.

Transportation Research Board, National Research Council. Transit Cooperative Research Program. Research Results Digest. "An Evaluation of the Relationship Between Transit and Urban Form." June 1996, Number 7.

US Census. 1990

U.S. Department of Transportation, Federal Highway Administration. “National Bicycling and Walking Study, Case Study 1, Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes.” Publication No. FHWA-PD-92-041. No date.

U.S. Department of Transportation, Federal Highway Administration. “National Bicycling and Walking Study, Case Study 3, What Needs to be Done to Promote Bicycling and Walking?” Publication No. FHWA-PD-93-039. February 26, 1992.

U.S. Department of Transportation, Federal Highway Administration. “National Bicycling and Walking Study, Case Study 4, Measures to Overcome Impediments to Bicycling and Walking.” August 1993.

U.S. Department of Transportation, Federal Highway Administration. “National Bicycling and Walking Study, Case Study 15, The Environmental Benefits of Bicycling and Walking.” Publication No. FHWA-PD-93-015. January 1993

Appendix E. California Air District Contacts

CALIFORNIA AIR POLLUTION CONTROL DISTRICTS
(URBEMIS Contacts and General Phone Numbers)

AMADOR COUNTY APCD (all of Amador County)
665 New York Ranch Road, #3
Jackson, CA 95642-2310 (209) 257-0112

ANTELOPE VALLEY APCD (NE portion of Los Angeles County)
43301 Division St., Ste. 206
P.O. Box 4409
Lancaster, CA 93539-4409 (661) 723-8070

BAY AREA AQMD (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, W portion of Solano, and S portion of Sonoma counties)
939 Ellis Street
San Francisco, CA 94109-7714
Henry Hilken (415) 771-6000

BUTTE COUNTY AQMD (all of Butte County)
2525 Dominic Drive, Suite J
Chico, CA 95928-7184
Gail Williams (530) 891-2882

CALAVERAS COUNTY APCD (all of Calaveras County)
Government Center
891 Mountain Ranch Rd.
San Andreas, CA 95249-9709 (209)754-6504

COLUSA COUNTY APCD (all of Colusa County)
100 Sunrise Blvd. #F
Colusa, CA 95932-3246
Bonnie McCullough (530) 458-0590

EL DORADO COUNTY APCD (all of El Dorado County)
2850 Fairlane Ct., Bldg. C
Placerville, CA 95667-4100
Dennis Otani (530) 621-6662

FEATHER RIVER AQMD (all of Sutter and Yuba counties)
938 14th Street
Marysville, CA 95901-4149
Larry Matlock (530) 634-7659

CALIFORNIA AIR POLLUTION CONTROL DISTRICT CONTACTS
(continued)

GLENN COUNTY APCD (all of Glenn County)
P.O. Box 351 (720 N. Colusa St.)
Willows, CA 95988-0351
Kevin Toganowa (530) 934-6500

GREAT BASIN UNIFIED APCD (all of Alpine, Inyo, and Mono counties)
157 Short Street, Suite 6
Bishop, CA 93514-3537
Duane Ono (760) 872-8211

IMPERIAL COUNTY APCD (all of Imperial County)
150 South 9th Street
El Centro, CA 92243-2801
Deputy AQCO – Reyes Romero (760) 482-4606

KERN COUNTY APCD (E portion of Kern County)
2700 "M" Street, Suite 302
Bakersfield, CA 93301-2370 (661) 862-5250

LAKE COUNTY AQMD (all of Lake County)
883 Lakeport Blvd.
Lakeport, CA 95453-5405 (707) 263-7000

LASSEN COUNTY APCD (all of Lassen County)
175 Russell Avenue
Susanville, CA 96130-4215 (530) 251-8110

MARIPOSA COUNTY APCD (all of Mariposa County)
P.O. Box 2039 (5101 Jones St.)
Mariposa, CA 95338-2039 (209) 966-2220

MENDOCINO COUNTY AQMD (all of Mendocino County)
306 E. Gobbi St.
Ukiah, CA 95482-5511 (707) 463-4354
Chris Brown

MODOC COUNTY APCD (all of Modoc County)
202 West 4th Street
Alturas, CA 96101-3915 (530)-233-6419

MOJAVE DESERT AQMD (N portion of San Bernardino County, & E portion of Riverside County)
15428 Civic Drive, Suite 200
Victorville, CA 92392-2383 (760) 245-1661

CALIFORNIA AIR POLLUTION CONTROL DISTRICT CONTACTS
(continued)

MONTEREY BAY UNIFIED APCD (all of Monterey, San Benito, Santa Cruz counties)
24580 Silver Cloud Ct.
Monterey, CA 93940-6536
Janet Brennan (831) 647-9411

NORTH COAST UNIFIED AQMD
2389 Myrtle Avenue
Eureka, CA 95501 (707) 443-3093

NORTHERN SIERRA AQMD (all of Nevada, Plumas, Sierra counties)
200 Litton Dr., Suite 320
P.O. Box 2509
Grass Valley, CA 95945-2509
APCO – Gretchen Bennitt (530) 274-9360

NORTHERN SONOMA COUNTY APCD (N portion of Sonoma County)
150 Matheson Street
Healdsburg, CA 95448-4908
APCO - Barbara Lee (707) 433-5911

PLACER COUNTY APCD (all of Placer County)
DeWitt Center
11464 "B" Ave.
Auburn, CA 95603-2603
Dave Vintze (530) 889-7130

SACRAMENTO METRO AQMD (all of Sacramento County)
8411 Jackson Rd.
Sacramento, CA 95826-3904
Matt Jones/Greg Tholen (916) 874-4800

SAN DIEGO COUNTY APCD (all of San Diego County)
9150 Chesapeake Dr.
San Diego, CA 92123-1096
Robert Reider (858) 650-4700

SAN JOAQUIN VALLEY UNIFIED APCD (all of Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, and W portion of Kern counties)
1999 Tuolumne, Ste. 200
Fresno, CA 93721-1638
(Central - Fresno)
Dave Mitchell (559) 230-6000-1075
(North - Modesto)
John Cadrett (209) 557-6400

CALIFORNIA AIR POLLUTION CONTROL DISTRICT CONTACTS
(continued)

SAN LUIS OBISPO COUNTY APCD (all of San Luis Obispo County)
3433 Roberto Court
San Luis Obispo, CA 93401-7126
Randy LaVack/Larry Allen (805) 781-1002

SANTA BARBARA COUNTY APCD (all of Santa Barbara County)
26 Castilian Dr. Suite B-23
Goleta, CA 93117-3027
Vijaya Jammalamadaka (805) 961-8800

SHASTA COUNTY AQMD (all of Shasta County)
1855 Placer Street, Ste. 101
Redding, CA 96001-1759 (530) 225-5674

SISKIYOU COUNTY APCD (all of Siskiyou County)
525 So. Foothill Dr.
Yreka, CA 96097-3036 (530) 841-4029

SOUTH COAST AQMD (Los Angeles County [except for area within the Antelope Valley APCD], Orange County, W portion of San Bernardino and W portion of Riverside counties)
21865 E. Copley Dr.
Diamond Bar, CA 91765-4182
Steve Smith / Mike Krause (909) 396-3054 or (909) 396-2526

TEHAMA COUNTY APCD (all of Tehama County)
P.O. Box 38 (1750 Walnut St.)
Red Bluff, CA 96080-0038 (530) 527-3717

TUOLUMNE COUNTY APCD (all of Tuolumne County)
22365 Airport
Columbia, CA 95310 (209) 533-5693

VENTURA COUNTY APCD (all of Ventura County)
669 County Square Dr., 2nd Fl.
Ventura, CA 93003-5417
Chuck Thomas (805) 645-1400

YOLO-SOLANO AQMD (all of Yolo and E portion of Solano counties)
1947 Galileo Ct., Ste. 103
Davis, CA 95616-4882
Dan O’Brien / Carl Vandagriff (530) 757-3650

Appendix F. State Of California Counties And Air Basins

A map is available on the internet at:

www.arb.ca.gov/emisinv/maps/statemap/dismap.htm

and also at:

www.arb.ca.gov/capcoa/roster.htm

Appendix G. Average Summer and Winter Temperatures

Appendix G. Average Summer And Winter Temperatures

AVERAGE SUMMER OZONE TEMPERATURES						
AIR BASIN	**COUNTY**	6 a.m. to 9 Am.	9 a.m. to noon	noon to 3 p.m.	3 p.m. to 6 p.m.	Average Temperature
Great Basin	Alpine	57	70	72	68	67
	Inyo	72	90	97	93	88
	Mono	63	79	79	79	75
Lake County	Lake	71	87	94	91	86
Lake Tahoe	El Dorado*	55	74	78	75	71
	Placer*	55	74	78	75	71
Mountain Counties	Amador	80	87	90	89	87
	Calaveras	80	87	90	89	87
	El Dorado*	72	82	85	85	81
	Mariposa	80	87	90	89	87
	Nevada	71	80	84	83	80
	Placer*	80	85	88	88	85
	Plumas	71	80	84	83	80
	Sierra	71	80	84	83	80
	Tuolunme	80	87	90	89	87
North Coast	Del Norte	51	55	57	57	55
	Humbolt	51	55	57	57	55
	Mendocino	51	55	57	57	55
	Sonoma*	51	55	57	57	55
	Trinity	54	79	87	87	77
North Central Coast	Monterey	56	70	78	73	69
	San Benito	57	72	79	74	71
	Santa Cruz	52	70	83	78	71
North East Plateau	Lassen	60	74	82	83	75
	Modoc	47	70	80	80	69
	Siskiyou	60	74	82	83	75
South Coast	Los Angeles*	74	85	89	83	83
	Orange	70	80	83	80	78
	Riverside*	78	92	98	93	90
	San Bernadino*	76	92	98	93	90
South Central Coast	San Luis Obispo	64	80	85	79	77
	Santa Barbara	66	72	77	75	73
	Ventura	67	77	78	73	74

* Parts of some counties are located in more than one air basin. Use the county and air basin in which the project is located.

Appendix G. Average Summer And Winter Temperatures

AVERAGE SUMMER OZONE TEMPERATURES						
AIR BASIN	**COUNTY**	6 a.m. to 9 a.m.	9 a.m. to noon	noon to 3 p.m.	3 p.m. to 6 p.m.	Average Temperature
San Diego	San Diego	70	88	91	85	84
South East Desert	Imperial	90	99	105	103	99
	Kern*	84	96	101	99	95
	Los Angeles*	79	91	96	91	89
	Riverside*	86	97	101	99	96
	San Bernadino*	82	94	101	101	95
San Francisco	Alameda	64	74	82	80	75
	Contra Costa	66	82	92	95	84
	Marin	57	76	89	92	79
	Napa	66	82	93	91	83
	San Francisco	67	83	87	77	79
	San Mateo	62	73	83	80	75
	Santa Clara	66	80	90	89	81
	Solano*	67	83	94	96	85
	Sonoma*	59	81	94	92	82
San Joaquin Valley	Fresno	73	88	98	102	90
	Kern*	78	89	97	100	91
	Kings	73	88	96	100	89
	Madera	71	86	96	99	88
	Merced	70	84	94	96	86
	San Joaquin	66	77	91	93	82
	Stanislaus	67	73	91	94	81
	Tulare	73	87	95	97	88
Sacramento Valley	Butte	75	87	97	99	90
	Colusa	71	87	97	99	89
	Glenn	76	91	99	100	92
	Placer*	80	85	88	88	85
	Sacramento	69	84	97	100	88
	Shasta	74	93	103	105	94
	Solano*	67	83	94	96	85
	Sutter	77	92	99	100	92
	Tehama	75	92	101	103	93
	Yolo	66	82	95	97	85
	Yuba	77	92	99	100	92

* Parts of some counties are located in more than one air basin. Use the county and air basin in which the project is located.

Appendix G. Average Summer And Winter Temperatures

AVERAGE WINTER CARBON MONOXIDE TEMPERATURES						
AIR BASIN	**COUNTY**	6 a.m. to 9 a.m.	9 a.m. to noon	noon to 3 p.m.	3 p.m. to 6 p.m.	Average Temperature
Great Basin	Alpine	18	26	34	28	27
	Inyo	19	46	48	28	35
	Mono	18	26	34	28	27
Lake County	Lake	39	48	60	59	52
Lake Tahoe	El Dorado*	16	32	40	33	30
	Placer*	39	52	48	46	46
Mountain Counties	Amador	23	39	44	32	35
	Calaveras	23	39	44	32	35
	El Dorado*	16	32	40	33	30
	Mariposa	37	43	41	38	40
	Nevada	35	45	57	52	47
	Placer*	39	52	48	46	46
	Plumas	36	46	47	43	43
	Sierra	35	45	57	52	47
	Tuolunme	23	39	44	32	35
North Coast	Del Norte	39	48	60	59	52
	Humbolt	39	48	60	59	52
	Mendocino	39	48	60	59	52
	Sonoma*	39	48	60	59	52
	Trinity	39	48	60	59	52
North Central Coast	Monterey	41	51	60	58	53
	San Benito	50	59	65	60	59
	Santa Cruz	47	58	66	65	59
North East Plateau	Lassen	19	30	47	44	35
	Modoc	19	30	47	44	35
	Siskiyou	28	34	41	40	36
South Coast	Los Angeles*	52	68	72	64	64
	Orange	53	67	71	66	64
	Riverside*	56	72	75	68	68
	San Bernadino*	53	72	79	73	69
South Central Coast	San Luis Obispo	39	56	70	66	58
	Santa Barbara	51	64	70	64	62
	Ventura	55	64	68	64	63

- Parts of some counties are located in more than one air basin. Use the county and air basin in which the project is located.

Appendix G. Average Summer And Winter Temperatures

AVERAGE WINTER CARBON MONOXIDE TEMPERATURES						
AIR BASIN	**COUNTY**	6 a.m. to 9 a.m.	9 a.m. to noon	noon to 3 p.m.	3 p.m. to 6 p.m.	Average Temperature
San Diego	San Diego	48	68	76	69	**65**
South East Desert	Imperial	52	72	81	75	**70**
	Kern*	41	57	64	59	**55**
	Los Angeles*	35	52	63	60	**53**
	Riverside*	50	64	70	66	**63**
	San Bernadino*	48	61	71	68	**62**
San Francisco	Alameda	50	57	62	60	**57**
	Contra Costa	40	49	58	57	**51**
	Marin	42	58	66	62	**57**
	Napa	40	50	59	58	**52**
	San Francisco	47	57	61	55	**55**
	San Mateo	47	57	61	55	**55**
	Santa Clara	47	60	68	64	**60**
	Solano*	40	50	59	58	**52**
	Sonoma*	42	58	66	62	**57**
San Joaquin Valley	Fresno	38	51	64	67	**55**
	Kern*	34	45	57	57	**48**
	Kings	37	48	62	61	**52**
	Madera	43	53	56	50	**51**
	Merced	42	52	63	64	**55**
	San Joaquin	39	52	64	61	**54**
	Stanislaus	42	57	67	62	**57**
	Tulare	38	54	64	60	**54**
Sacramento Valley	Butte	39	51	62	62	**54**
	Colusa	37	52	64	61	**54**
	Glenn	39	55	67	63	**56**
	Placer*	39	52	61	63	**54**
	Sacramento	39	52	61	63	**54**
	Shasta	36	45	53	52	**47**
	Solano*	36	47	57	57	**49**
	Sutter	33	37	48	55	**43**
	Tehama	42	57	66	61	**57**
	Yolo	36	47	57	57	**49**
	Yuba	39	51	62	62	**54**

- Parts of some counties are located in more than one air basin. Use the county and air basin in which the project is located.
- Source: Calif. ARB

Appendix H. Construction Equipment Emission Factors

The grams per brake-horsepower-hour emission factors shown below were used to estimate total daily emissions for off-road construction equipment. The grams/brake-hp-hr values were developed using the following approach. Pre-1996 emission factors were based on actual emissions of off-road equipment included in the California Air Resources Board's Off-Road model database. They represent average emissions over all horsepower classes. Emission factors for 1996 and later years were based on allowable emission rates for California off-road construction equipment.

	grams/brake-hp-hr			
Year	ROG	CO	NOx	PM10
Pre-1996	1.00	4.09	11.73	0.59
1996-2000	1.00	8.5	6.9	0.4
2001+	1.00	8.5	5.8	0.16

The table below shows the daily emissions in pounds that URBEMIS calculates for each piece of construction equipment using the default horsepower, load factors, and hours per day included in URBEMIS2002.

Bore rigs have a default horsepower of 218, a 0.75 load factor, and are assumed to operate 8 hours per day. These values are multiplied together and by the appropriate emission rate to obtain daily emissions. URBEMIS uses a weighted emission rate that is based on the average composition of the fleet. Emissions are weighted by the average turnover of the particular vehicle. Vehicle turnover rates are found in the notes following the table below. Bore rigs have an average annual turnover rate of 33%. Therefore, by 2003, 100% of the emissions are based on the 2001+ emission rates. Using the 2001+ emission rates and the vehicle default values for horsepower, load factor, and hours per day, URBEMIS calculates emissions using the following equation to obtain the values shown in the table below:

Emissions (pounds/day) = grams/brake-hp-hour x horsepower x load factor x hours per day x pound/454 grams

As an example, NOx emissions for one bore rig in 2003 are calculated as follows:
NOx emissions (pounds/day) = 5.8 grams/brake-hp-hr x 218 hp x 0.75 (load factor) x 8 hours per day x pound/454 grams

NOx emissions = 16.71 pounds per day

Construction Equipment Emission Rates for 2000–2010 (pounds per day)

Bore/Drill Rigs	ROG	CO	NOx	PM10	Paving Equipment	ROG	CO	NOx	PM10
2000	2.88	24.45	19.88	1.15	2000	1.03	5.66	10.59	0.55
2001	2.88	24.45	18.81	0.90	2001	1.03	5.95	10.20	0.52
2002	2.88	24.45	17.78	0.69	2002	1.04	6.23	9.82	0.49
2003	2.88	24.45	16.71	0.46	2003	1.04	6.52	9.44	0.46
2004	2.88	24.45	16.71	0.46	2004	1.04	6.81	9.05	0.44
2005	2.88	24.45	16.71	0.46	2005	1.04	7.09	8.67	0.41
2006	2.88	24.45	16.71	0.46	2006	1.04	7.38	8.28	0.38
2007	2.88	24.45	16.71	0.46	2007	1.04	7.66	7.90	0.35
2008	2.88	24.45	16.71	0.46	2008	1.04	7.95	7.52	0.33

Construction Equipment Emission Rates for 2000–2010 (pounds per day)									
2009	2.88	24.45	16.71	0.46	2009	1.04	8.23	7.13	0.30
2010	2.88	24.45	16.71	0.46	2010	1.04	8.52	6.75	0.27
Concrete/Industrial Saws	ROG	CO	NOx	PM10	Rollers	ROG	CO	NOx	PM10
2000	1.08	5.89	11.01	0.57	2000	0.86	5.91	7.52	0.41
2001	1.08	6.18	10.61	0.54	2001	0.86	6.39	6.88	0.36
2002	1.08	6.48	10.21	0.51	2002	0.86	6.86	6.24	0.31
2003	1.08	6.78	9.81	0.48	2003	0.86	7.34	5.60	0.27
2004	1.08	7.08	9.41	0.45	2004	0.86	7.34	5.48	0.24
2005	1.08	7.37	9.01	0.43	2005	0.86	7.34	5.36	0.22
2006	1.08	7.67	8.61	0.40	2006	0.86	7.34	5.24	0.19
2007	1.08	7.97	8.21	0.37	2007	0.86	7.34	5.13	0.16
2008	1.08	8.26	7.81	0.34	2008	0.86	7.34	5.01	0.14
2009	1.08	8.56	7.41	0.31	2009	0.86	7.34	5.01	0.14
2010	1.08	8.86	7.02	0.28	2010	0.86	7.34	5.01	0.14
Cranes	ROG	CO	NOx	PM10	Rough Terrain Forklifts	ROG	CO	NOx	PM10
2000	1.44	9.44	13.05	0.70	2000	0.79	5.40	6.87	0.37
2001	1.44	10.14	12.10	0.63	2001	0.79	5.83	6.29	0.33
2002	1.44	10.85	11.15	0.56	2002	0.79	6.27	5.70	0.29
2003	1.44	11.56	10.20	0.49	2003	0.79	6.70	5.12	0.24
2004	1.44	12.27	9.25	0.42	2004	0.79	6.70	5.01	0.22
2005	1.44	12.27	9.07	0.38	2005	0.79	6.70	4.90	0.20
2006	1.44	12.27	8.90	0.35	2006	0.79	6.70	4.79	0.17
2007	1.44	12.27	8.72	0.31	2007	0.79	6.70	4.68	0.15
2008	1.44	12.27	8.55	0.27	2008	0.79	6.70	4.57	0.13
2009	1.44	12.27	8.37	0.23	2009	0.79	6.70	4.57	0.13
2010	1.44	12.27	8.37	0.23	2010	0.79	6.70	4.57	0.13
Crawler Tractors	ROG	CO	NOx	PM10	Rubber-Tired Dozers	ROG	CO	NOx	PM10
2000	1.45	7.94	14.85	0.77	2000	3.66	20.03	37.45	1.93
2001	1.45	8.34	14.31	0.73	2001	3.66	21.04	36.10	1.84
2002	1.45	8.74	13.77	0.69	2002	3.66	22.05	34.74	1.74
2003	1.45	9.14	13.23	0.65	2003	3.66	23.06	33.38	1.64
2004	1.45	9.54	12.69	0.61	2004	3.66	24.07	32.02	1.54
2005	1.45	9.95	12.16	0.57	2005	3.66	25.09	30.66	1.45
2006	1.45	10.35	11.62	0.53	2006	3.66	26.10	29.31	1.35
2007	1.45	10.75	11.08	0.50	2007	3.66	27.11	27.95	1.25
2008	1.45	11.15	10.54	0.46	2008	3.66	28.12	26.59	1.15
2009	1.45	11.55	10.00	0.42	2009	3.66	29.13	25.23	1.06
2010	1.45	11.95	9.46	0.38	2010	3.66	30.14	23.87	0.96
Crushing/Proc. Equipment	ROG	CO	NOx	PM10	Rubber-Tired Loaders	ROG	CO	NOx	PM10
2000	2.12	11.60	21.68	1.12	2000	1.35	9.27	11.80	0.64
2001	2.12	12.18	20.89	1.06	2001	1.35	10.02	10.80	0.56
2002	2.12	12.77	20.11	1.01	2002	1.35	10.77	9.79	0.49
2003	2.12	13.35	19.32	0.95	2003	1.35	11.52	8.79	0.42
2004	2.12	13.94	18.53	0.89	2004	1.35	11.52	8.60	0.38
2005	2.12	14.52	17.75	0.84	2005	1.35	11.52	8.42	0.34
2006	2.12	15.11	16.96	0.78	2006	1.35	11.52	8.23	0.30
2007	2.12	15.69	16.18	0.72	2007	1.35	11.52	8.04	0.26
2008	2.12	16.28	15.39	0.67	2008	1.35	11.52	7.86	0.22
2009	2.12	16.86	14.60	0.61	2009	1.35	11.52	7.86	0.22
2010	2.12	17.45	13.82	0.55	2010	1.35	11.52	7.86	0.22
Excavators	ROG	CO	NOx	PM10	Scrapers	ROG	CO	NOx	PM10

Construction Equipment Emission Rates for 2000–2010 (pounds per day)									
2000	1.84	13.32	15.24	0.83	2000	3.64	21.58	35.39	1.85
2001	1.84	14.48	13.68	0.72	2001	3.64	22.92	33.59	1.72
2002	1.84	15.64	12.12	0.61	2002	3.64	24.26	31.79	1.59
2003	1.84	15.64	11.83	0.55	2003	3.64	25.60	29.99	1.46
2004	1.84	15.64	11.54	0.48	2004	3.64	26.94	28.19	1.33
2005	1.84	15.64	11.25	0.42	2005	3.64	28.28	26.39	1.21
2006	1.84	15.64	10.96	0.36	2006	3.64	29.62	24.59	1.08
2007	1.84	15.64	10.67	0.29	2007	3.64	30.96	22.79	0.95
2008	1.84	15.64	10.67	0.29	2008	3.64	30.96	22.46	0.87
2009	1.84	15.64	10.67	0.29	2009	3.64	30.96	22.13	0.80
2010	1.84	15.64	10.67	0.29	2010	3.64	30.96	21.79	0.73
Graders	ROG	CO	NOx	PM10	Signal Boards	ROG	CO	NOx	PM10
2000	1.76	11.09	16.42	0.87	2000	1.72	9.39	17.55	0.91
2001	1.76	11.87	15.37	0.79	2001	1.72	9.86	16.91	0.86
2002	1.76	12.65	14.33	0.72	2002	1.72	10.33	16.28	0.81
2003	1.76	13.43	13.28	0.64	2003	1.72	10.81	15.64	0.77
2004	1.76	14.21	12.24	0.57	2004	1.72	11.28	15.00	0.72
2005	1.76	14.98	11.19	0.49	2005	1.72	11.75	14.37	0.68
2006	1.76	14.98	11.00	0.45	2006	1.72	12.23	13.73	0.63
2007	1.76	14.98	10.81	0.41	2007	1.72	12.70	13.10	0.59
2008	1.76	14.98	10.61	0.37	2008	1.72	13.18	12.46	0.54
2009	1.76	14.98	10.42	0.32	2009	1.72	13.65	11.82	0.49
2010	1.76	14.98	10.22	0.28	2010	1.72	14.12	11.19	0.45
Off-Highway Tractors	ROG	CO	NOx	PM10	Skid Steer Loaders	ROG	CO	NOx	PM10
2000	1.84	10.07	18.83	0.97	2000	0.56	4.78	3.88	0.23
2001	1.84	10.58	18.15	0.92	2001	0.56	4.78	3.76	0.20
2002	1.84	11.09	17.47	0.87	2002	0.56	4.78	3.63	0.17
2003	1.84	11.60	16.78	0.83	2003	0.56	4.78	3.51	0.14
2004	1.84	12.11	16.10	0.78	2004	0.56	4.78	3.39	0.12
2005	1.84	12.61	15.42	0.73	2005	0.56	4.78	3.26	0.09
2006	1.84	13.12	14.74	0.68	2006	0.56	4.78	3.26	0.09
2007	1.84	13.63	14.05	0.63	2007	0.56	4.78	3.26	0.09
2008	1.84	14.14	13.37	0.58	2008	0.56	4.78	3.26	0.09
2009	1.84	14.65	12.69	0.53	2009	0.56	4.78	3.26	0.09
2010	1.84	15.16	12.00	0.48	2010	0.56	4.78	3.26	0.09
Off-Highway Trucks	ROG	CO	NOx	PM10	Surfacing Equipment	ROG	CO	NOx	PM10
2000	3.60	22.67	33.55	1.78	2000	3.77	20.62	38.56	1.99
2001	3.60	24.26	31.42	1.62	2001	3.77	21.66	37.16	1.89
2002	3.60	25.85	29.28	1.47	2002	3.77	22.70	35.76	1.79
2003	3.60	27.44	27.15	1.32	2003	3.77	23.75	34.36	1.69
2004	3.60	29.03	25.01	1.16	2004	3.77	24.79	32.97	1.59
2005	3.60	30.62	22.87	1.01	2005	3.77	25.83	31.57	1.49
2006	3.60	30.62	22.48	0.92	2006	3.77	26.87	30.17	1.39
2007	3.60	30.62	22.08	0.84	2007	3.77	27.91	28.77	1.29
2008	3.60	30.62	21.69	0.75	2008	3.77	28.95	27.37	1.19
2009	3.60	30.62	21.29	0.66	2009	3.77	29.99	25.98	1.09
2010	3.60	30.62	20.89	0.58	2010	3.77	31.03	24.58	0.99
Other Construction Equipment	ROG	CO	NOx	PM10	Tractors/Loaders/Backhoes	ROG	CO	NOx	PM10
2000	2.08	11.37	21.26	1.10	2000	0.65	3.56	6.66	0.34
2001	2.08	11.95	20.49	1.04	2001	0.65	3.74	6.42	0.33
2002	2.08	12.52	19.72	0.99	2002	0.65	3.92	6.17	0.31

Construction Equipment Emission Rates for 2000–2010 (pounds per day)									
2003	2.08	13.09	18.95	0.93	2003	0.65	4.10	5.93	0.29
2004	2.08	13.67	18.18	0.88	2004	0.65	4.28	5.69	0.27
2005	2.08	14.24	17.41	0.82	2005	0.65	4.46	5.45	0.26
2006	2.08	14.82	16.64	0.77	2006	0.65	4.64	5.21	0.24
2007	2.08	15.39	15.87	0.71	2007	0.65	4.82	4.97	0.22
2008	2.08	15.96	15.10	0.66	2008	0.65	5.00	4.73	0.21
2009	2.08	16.54	14.32	0.60	2009	0.65	5.18	4.48	0.19
2010	2.08	17.11	13.55	0.54	2010	0.65	5.36	4.24	0.17
Pavers	ROG	CO	NOx	PM10	Trenchers	ROG	CO	NOx	PM10
2000	1.37	9.36	11.91	0.64	2000	1.00	7.26	8.31	0.45
2001	1.37	10.12	10.90	0.57	2001	1.00	7.90	7.46	0.39
2002	1.37	10.87	9.89	0.50	2002	1.00	8.53	6.61	0.33
2003	1.37	11.62	8.87	0.42	2003	1.00	8.53	6.45	0.30
2004	1.37	11.62	8.68	0.38	2004	1.00	8.53	6.29	0.26
2005	1.37	11.62	8.50	0.34	2005	1.00	8.53	6.14	0.23
2006	1.37	11.62	8.31	0.30	2006	1.00	8.53	5.98	0.19
2007	1.37	11.62	8.12	0.26	2007	1.00	8.53	5.82	0.16
2008	1.37	11.62	7.93	0.22	2008	1.00	8.53	5.82	0.16
2009	1.37	11.62	7.93	0.22	2009	1.00	8.53	5.82	0.16
2010	1.37	11.62	7.93	0.22	2010	1.00	8.53	5.82	0.16

Notes: Emissions rates are based on ARB's off-road emissions model. Daily emissions are based on specified horsepower, hours per day of operation, and load factor used as defaults in the URBEMIS2002 model. Annual emission rates by construction vehicle type are in grams per horsepower hour and are fleet averages based on vehicle turnover rates. The turnover rates assumed by vehicle type are as follows:

Bore/Drill Rigs: 3 years
Concrete/Industrial Saws: 16 years
Cranes: 9 years
Crawler Tractors: 16 years
Crushing/Proc. Equipment: 16 years
Excavators: 7 years
Graders: 10 years
Off-Highway Tractors: 16 years
Off-Highway Trucks: 10 years
Other Construction Equipment: 16 years
Pavers: 8 years
Paving Equipment: 16 years
Rollers: 8 years
Rough Terrain Forklifts: 8 years
Rubber Tired Dozers: 16 years
Rubber Tired Loaders: 8 years
Scrapers: 12 years
Signal Boards: 16 years
Skid Steer Loaders: 5 years
Surfacing Equipment: 16 years
Tractors/Loaders/Backhoes: 16 years
Trenchers: 7 years